APPENDIX I.

REPORT

OF THE
TECHNICAL SUB-COMMITTEE
TO THE
COUNCIL OF THE INDIAN ROADS CONGRESS
FOR THE PERIOD
December 1939 to January 1941

(Considered by the Council vide resolution No 29 of its Proceedings dated the 28th January 1941 and accepted with remarks at Annex VI page 233)

1 The Committee appointed by the Council at its Meeting in December 1939, consisted of the following members, with power to co-opt

Mr K G Mitchell C I E (*President*)
Mr J A Stein
Mr W L Murrell, O B E
Mr Ian A T Shannon
Mr Syed Arifuddin
Mr A Lakshminarayana Rao
Mr H M Dunbar
Mr K S Raghavachary (*Secretary*)

2 *Meetings* The Committee has met five times in Calcutta in April June, September and December 1940 and in Delhi at intervals during the Council Session in January 1941 The meetings in Calcutta were convened sometimes at short notice, as the work on the Test Track required A list of the members and co-opted members that attended the several meetings is attached **Annex I.**

3 *Test Track at Majerhat Calcutta* (1) Progress so far has been slow, and no definite results can yet be pronounced, because of

(*a*) initial difficulties with the equipment

(*b*) the difficulties of testing surface treatments which on the road depend on traffic for their completion

(*c*) the undue severity of the tests first made and

(*d*) the necessity of stopping work during the monsoon

(2) The equipment designed by Mr Gilmore without previous experience of any similar installation in India and for a purpose somewhat different to that of test tracks elsewhere has on the whole proved remarkably efficient But unexpectedly severe stresses developed in certain parts which had eventually to be replaced and adjustments have had to be made to the oscillating gear to give the pitch of the lateral "throw" found in practice to be the best Changes have also been made in the test carts—two of them having to be fitted with pneumatic tyres These initial difficulties now appear to have been overcome, but owing to the war demands on mechanical workshops, delays will be inevitable if further alterations or replacements are necessary

(3) Surface treatments are, in practice, usually applied after the waterbound macadam has been subjected to traffic for a few weeks, some

final consolidation and closing of the pores being due to this traffic. After treatment the chip is driven into the binder and the road "surfaces up" under traffic. Various devices have been tried on the test track to reproduce the consolidation and ironing effect of traffic on the test strips. The latter can now be done reasonably well but the former cannot so that a surface treatment has to be applied to a more "open" medium than is often met with in practice and the test strips probably have less lateral support than they would in a road. We have however decided to carry out a further set of tests of surface treatment, which is about to be started because of the wide application of this form of construction and because it is better to get the equipment perfected and to obtain experience in its operation on the less expensive specifications before attempting precise tests on the more expensive.

(4) The cart tyre load per inch width varies greatly throughout India from a few hundred pounds to 1 500 and more. The first tests on the track were made with a load of 1 000 pounds per inch width. This, unalleviated by the ironing effect of lighter traffic proved too severe and aggravated by heavy rain brought the first series of tests to a sudden and somewhat inconclusive failure. The loading has now been reduced to 500 pounds per inch width.

(5) Surface treatment particularly as reproduced on the test track is not water proof and as already stated the first set of test lengths failed suddenly under test after heavy rain. The whole of the sub grade at this site is liable to become water logged and an elaborate drainage system has been put in despite which it was at one time feared that failure of the test lengths was due to yielding of the foundation. The Committee are satisfied that this was not the case to any substantial degree. Even after the severe test with 1 000 pounds per inch width of tyre during or after the rains the settlement shown by a number of sections cut across the track was trifling. What set there was, moreover, may now be assumed for all practical purposes to have been final. In short, the foundations are above suspicion. Nevertheless surface treatments are not water proof, the hard Pakur stone requires a considerable amount of hoggin. The road crust may become water logged after heavy rain, and reliable tests cannot then be made.

(6) *Tests carried out.* The first set of tests were commenced in December 1938, the test lengths breaking down during the monsoon of 1939 for reasons already given. The tests having been inconclusive particulars are not given. The work then remained in abeyance for a time pending a decision whether the Test Track should be closed during the war. When the Committee met in April 1941 it was decided to continue by repeating the first tests with certain modifications as follows:—

(i) The pitch of [illegible] on one track would remain as before at 36 feet, that on the other being increased to 42 feet in order to ascertain the pitch most fairly representing road conditions.

(ii) One cart on each track to be loaded to 500 pounds per inch width of steel tyre (edges of tyres being chamfered) and one cart to be fitted with pneumatic tyres each wheel being loaded to 1 500 pounds.

(iii) Half the length of each track, [illegible] and each [illegible] to be laid with cold premix and half with hot premix.

(iv) The test strips to be ironed out before test by the use of pneumatic tyres only

The stones as before were Pakur Pathankot Delhi and Jhansi

These tests were not concluded before the monsoon and work was frequently stopped after it broke There were however considerable breaks when testing could be continued and the various lengths had been tested practically to destruction by the end of September 1940 when the Committee inspected the track and recorded certain provisional findings (*vide* Minutes of the Meeting on 30th September 1940) (Annex IV) The Committee decided to repeat another series of tests with certain further modifications and is not in the meantime prepared to report any provisional conclusions They believe however that the initial difficulties have been overcome and that valuable and reliable results should now be obtained At the date of the report the next set of tests which they recommend had not been commenced owing to delay in the supply of new gearing to increase the pitch of the throw on the second track to 48 feet They hope that this will be supplied in time for this set of tests to be completed before the monsoon On completion the Committee will report the conclusions which they have reached

4 *Correlation between Test Track results and those of experiments on the road* At one time the Committee recommended that the tests made on the Test Track should as a check be reproduced in a number of road trials throughout India On consideration they feel that the number of variables involved of traffic climate standard of workmanship and quantities of binder required by these local conditions would lead to more confusion than correlation and they propose to limit the control road tests to that already being laid down in Delhi and to one comparing the behaviour of the various primers and binders in combination with Delhi and Jhansi stones under conditions as nearly identical as possible which Mr Mahabir Prasad Chief Engineer United Provinces has undertaken to carry out at some place where the cost of both the stones is approximately the same

5 *Experimental work on the Great Northern Trunk Road Madras*

(i) An extensive series of test lengths consisting of cement concrete premixes and surface dressings with tar and with Mexphalte and Socony Bitumen amounting in all to about 7½ miles were laid in 1937 38 and as part of the cost was defrayed by the Government of India the Committee was asked at its meeting in April 1940 to consider a report on these experiments and in particular the cause of failure of certain sections The Committee was handicapped by being unable to inspect the road and could only put forward (*vide* Minutes of the Meeting on 11th April 1940) (Annex II) certain very general propositions

(ii) The width of the carriageway varied between 20 and 23 feet The traffic was of the order of 1 400 tons per 24 hours with a high proportion of steel tyred bullock carts Tracking by carts and consequent localised wear was prominent The lighter types of work particularly surface dressing had generally failed by 1940 and the tar sections appeared to have faired worst but the Committee were not in view of the success of tar elsewhere,

prepared, on the information before them, to condemn that material and found in general terms —

(*a*) The value of large-scale experiments of this nature depends very largely upon the various surfaces being adequately maintained until abandoned as being too expensive At the end of a period of years, it would then be possible to estimate the total cost of each section in respect of first cost, maintenance over a period of years up to the time of replacement, and cost of replacement

(*b*) In this it is intended to keep the records upto 1943 only but it is suggested that they should be kept for such longer period as might be necessary in order to furnish a reliable comparison between the different specification,

(*c*) Inadequate maintenance and observation of and lack of careful attention to experimental surfaces, are too common They are due partly to lack of continuity in personnel, lack of systematised records and lack of funds for maintenance The latter difficulty is often due to budget technicalities The Committee recommend that, as a general rule, no experimental roads should be laid unless special arrangements are made to reserve funds at the disposal of the Chief Engineer or, if necessary, the Superintending Engineer to ensure that everything which is necessary is done promptly If after a year or two it appears that the maintenance of certain surface is too expensive, it can, on those grounds, be rejected and replaced by something else But it is not a fair trial of specifications of different strength and varying first cost under the same intense traffic, unless the weaker specifications are maintained at the obviously higher cost necessarily involved in keeping them in repair

(*d*) The Committee further recommend that in such cases there should be prepared in advance an *estimate of the annual* expenditure necessary for maintenance and renewal of the various sections approved before the *experimental work is* put in hand The sums necessary, *and not those provided in the estimate*, should be expended on maintenance and renewal as required and there should be an annual report of the actual expenditure compared with the advance estimate.

(*e*) Where any experimental length is laid on a public road to the specification or on the advice or suggestion of the supplier of the bituminous or other material the time and matter of treatment of the road in the course of maintenance and renewal should normally be decided in consultation with that supplier The latter is clearly interested in proving that his material has stood a certain intensity of traffic over a period of years with the minimum maintenance expenditure and is the party most interested in avoiding, on one hand, lavish expenditure and, on the other, starvation leading to the premature destruction of the surface

(ii) The Committee felt itself unable to offer definite comments on the various failures except that obviously suggested by the very low 'Trench co-efficient" of the stone when wet which clearly requires constant attention and careful maintenance to protect the stone from direct action by the traffic during the monsoons

As a corollary the Committee remarked that the possibility of developing the Chikrayapuram quarry might well be further investigated

(iii) As a general recommendation adopted at a subsequent meeting (25th January 1941) the Committee suggest

(a) that no "binder" or "primer" should be described, in reference to any experimental or other work, discussed by the Committee, by its trade name unless there is no record with the Congress an adequate specification of the nature of the material, and

(b) that all bituminous materials (including tar) used in experimental work should be sampled and tested so as to ensure that the material satisfies the recorded specifications and that departures from that specification are brought to light.

6 *The use of primers with surface dressing* The Committee is indebted to Mr Murrell for reports on series of interesting tests with cold primers for the use before surface treatment of waterbound macadam particularly if in poor and ravelled condition The Committee believes that it is generally accepted that it is often advantageous to use a penetrating material which among other things, provides a 'shaded' adhesion between the surface of the macadam and the binder rather than a plane of cleavage But in view of the many hundreds of miles of unprimed surface treatment with a non penetrating material that have given good service the Committee is not prepared to say that the mechanical interlock between binder and macadam in those surfaces would in practice be improved by the addition of a primer Nor does the Committee at present believe that there is any merit, other than possible convenience of application in cold primers as compared with those that have to be heated At the same time they consider that Mr Murrell's suggestions should be followed up and that the value of primers—whether cold or hot—should be further examined This they propose to do both on the Test Track and on any "control" road tests made in correlation with the Test Track They have also accepted an offer by Mr Stein to devise and carry out certain tests to this end on the JHENIDA CHUADANGA road at present under construction in Bengal

7 *Standard Specification of sizes of stone* Mr Lakshminarayana Rao has pointed out to the Committee that the specifications adopted by the Congress do not reject 'needles' and are in that respect defective Doubt has also been expressed whether the specifications sufficiently accord in other respects with accepted good practice The Committee (*vide* item 4 of the Minutes of the Meeting on 11th April 1940) (Annex II) are investigating these questions but are not yet in a position to make any recommendations

8 *Proposals by Mr A K Datta that certain tests should be carried out at the Alipore Test House and at the Test Track.* Mr Datta's proposals included the testing of —

(1) *Bonded brick and boulder concrete as a substitute for all concrete in road slabs* In this connection the Committee believe that the saving in cement that can be effected by the use of stone or brick "plums" is often more than offset by the extra labour, cost of laying and by the risk of failure at planes of cleavage This type of work depends mainly on the ease, in practice, with which plum concrete can be laid in actual working conditions and that there is no precise problem for solution by test under laboratory or semi laboratory conditions

(2) *"Shaded' concrete for road slabs* (A weak mix below shaded to a rich mix above) In theory this proposal is sound In practice its success depends upon supervision and field working conditions. Small scale precise tests will not, in the view of the committee, help They await a report from Mr Stein in due course when any conclusions can be drawn from the behaviour of such concrete laid on the Ranaghat-Jaguli road in Bengal

(3) Mr Datta also proposed that 'silica cement 'village cement", bamboo strip reinforcement, and 'pozzolona molasses lime concrete should also be tested The Committee cannot recommend that these questions should be investigated either at the Test House or on the Test Track

9 *Soil Research* At its meeting on the 25th January 1941, the Committee sitting with certain members, received a report separately presented to the Council—on the progress made to date with this matter The committee observe that it appears that, in this matter also, progress has been retarded because of the inability of the Consulting Engineer to find time to supervise and stimulate this work in person This matter is referred to below

10 *Need for more adequate Organisation*

(i) The Committee feel that throughout the field of research and experiment there is an unfortunate lag in progress Whether on the Test Track or in relation to Soil Research or in pursuing the various recommendations of the Committee or of the Council in a number of other directions the value of the work of the Committee and the value of the Congress itself is being impaired by lack of drive The Committee feel that its members give up much time and thought to the questions brought before it but that the translation of their recommendations into practical use is neglected They understand that the time of the Consulting Engineer is already filled and that he can personally do no more than he is doing They are, therefore of the opinion that it is necessary to have a whole time Officer added to the Office of the Consulting Engineer to assist him to conduct and control research and to co-ordinate the experiments being made in the different Provinces and to make the results readily available, if substantial progress is to be achieved

(ii) The Committee further consider that for this work it is more important to select the right man than to pre-determine the

grade and scale of pay of the post From the Central Road Fund alone about 1½ crores of rupees are provided annually for road construction and precise considerations of cost should not prejudice the important requirements of research and intelligence The qualifications necessary are adequate experience of practical road engineering in India (say 7 years) exceptional theoretical knowledge and sound judgment The terms should be such as to attract and retain the best man available

(iii) The Committee recommend that long term planning is in present circumstances impracticable but they feel that whatever the future the results of research and experiment properly conducted now cannot fail to be valuable

11 The Minutes of the Proceedings of the Committee at its various Meetings are appended Annex II to X (with the exception of the proceedings at the meeting on the 24th and 25th January the substance of which has been incorporated in this report the minutes have already been circulated to members of the Committee They are not circulated to the Council at this stage but will be printed with the Proceedings of the Council)

ANNEX I

List of members who attended the meetings of the Technical Sub Committee

(a) Held on 11 4 40

1	Mr K G Mitchell C I E	(*President*)
2	J A Stein	
3	W I Murrell	
4	Ian A T Shannon	
5	Syed Arifuddin	
6	H M Dunbar	
7	M E Lloyd	Co opted members
8	C J Fielder	Co opted members
9	F F G Gilmore	Co opted members
10	N N Sen Gupta	Co opted members
11	Dr A N Chowdhary	Co opted members
12	Mr Jagdish Prasad	(*Secretary*)

(b) Held on 8 6 40

1	Mr K G Mitchell C I E	(*President*)
2	J A Stein	
3	Ian A T Shannon	
4	H M Dunbar	

5 Mr M E Lloyd
6 ,, W J Turnbull
7 ,, J R Hannington
8 , E F G Gilmore
9 ,, N N Sen Gupta
10 Dr A N Chowdhary

} Co opted members (5–10)

(c) Held on 30 9 40

1 Mr K G Mitchell, C I E (*President*)
2 ,, J A Stein
3 ,, W L Murrell
4 , Ian A T Shannon
5 ,, Syed Arifuddin
6 ,, H M Dunbar
7 ,, E F G Gilmore
8 ,, N N Sen Gupta
9 Dr A N Chowdhary
10 Mr C J Fielder
11. ,, I N Khanna
12 ,, K S Raghavachary (*Secretary*)

} Co opted members (7–11)

(d) Held on 16 12 40

1 Mr K G Mitchell C I E (*President*)
2 ,, J A Stein
3 ,, Ian A T Shannon
4 ,, E F G Gilmore
5 Dr A N Chowdhary.
6 Col G E Sopwith
7 Mr N Das Gupta
8 ,, W K Ashmead
9 ,, W J Turnbull
10 ,, C J Fielder

} Co opted members (4–10)

(e) Held on 25 1 41

1 Mr K G Mitchell C I E (*President*)
2 , J A Stein
3 ,, A Lakshminarayana Rao
4 ,, W L Murrell.
5 ,, Ian A T Shannon
6 ,, Syed Arifuddin
7 ,, Jagdish Prasad
8 , S R Mehra
9 ,, J Vesugar
10 ,, H B Parikh
11 ,, K S Raghavachary (*Secretary*)

} Co opted members (6–10)

ANNEX II

Minutes of meetings of the Technical Sub-Comm... Roads Congress held on the 11th April 1940 and sub... Council House Street Calcutta

Item 1 *To consider a note on the working of the Test T...* Committee discussed the history of the test track to date and ... position and adjourned further discussion pending exam... track in the afternoon

Item 2 *To consider a note reproduced at Annex I, page 2 ... experimental surfacings laid on the Great Northern Trunk Road with notes thereon by Mr Campbell Gray and Col Sopwith, pages ... respectively* Mr Dunbar mentioned that on certain sections ... where there is a strip of cement concrete on one side of the ro... bullock carts in both directions tend to use that strip and that the traffic figures for the remainder of the road are unreliab... figures are of course affected in this way whenever a road is wide to permit of segregation of different types of vehicle even its proper side of the road But the Congress has already reac... clusion that taking all factors into consideration the most accu... recording statistics is in total tonnage per 24 hours the width being stated) The Committee decided to ask the Chief Engin... to verify the fact

After some discussion the Committee recorded the following opinion —

(1) The value of large scale experiments of this nature depends very largely upon the various surfaces being adequately maintained until abandoned as being too expensive At the end of a period of years it would then be possible to estimate the total cost of each section in respect of (a) first cost (b) maintenance over a period of years upto the time of replacement and (c) cost of replacement

(2) In this case it is intended to keep the records upto 1943 only but it is suggested that they should be kept for such longer period as might be necessary in order to furnish a reliable comparison between the different specifications

(3) Inadequate maintenance and observation of and lack of careful attention to experimental surfaces are too common They are due partly to lack of continuity in personnel lack of systematised records and lack of funds for maintenance The latter difficulty is often due to budget technicalities The Committee recommend that as a general rule no experimental roads should be laid unless special arrangements are made to reserve funds at the disposal of the Chief Engineer or if necessary the Superintending Engineer to ensure that everything which is necessary is done promptly If after a year or two it appears that the maintenance of a certain surface is too expensive it can on those grounds be rejected and replaced by something else But it is not a fair trial of specifications of different strength

varying first cost under the same intense traffic, unless the weaker specifications are maintained at the obviously higher cost necessarily involved in keeping them in repair

(4) The Committee further recommend that in such cases there should be prepared in advance an estimate of the annual expenditure necessary for maintenance and renewal of the various sections approved before the experimental work is put in hand The sums necessary, *and not those provided in the estimate*, should be expended on maintenance and renewal as required and there should be an annual report of the actual expenditure compared with the advance estimate

(5) Where any experimental length is laid on a public road to the specification or on the advice or suggestion of the supplier of the bituminous or other material the time and manner of treatment of the road in the course of maintenance and renewal should normally be decided in consultation with that supplier The latter is clearly interested in proving that his material has stood a certain intensity of traffic over a period of years with the minimum maintenance expenditure and is the party most interested in avoiding on the one hand lavish expenditure and on the other, starvation leading to the premature destruction of the surface

(6) The Committee would be grateful if the Chief Engineer, Madras could supply a few photographs of the failure of certain sections by rutting for comparison with failures elsewhere

(7) The Committee ventured to suggest that, in conformity with its general recommendations above, the Chief Engineer, Madras, might be asked to see that the repairs necessary, however extensive, are now carried out on the various sections of this experiment, in order that, as far as may now be possible, comparable results on the basis of maintenance cost should be available

(8) The Committee expressed great interest in these experiments but felt itself unable to offer definite comments on the various failures except that obviously suggested by the very low ' French co efficient ' of the stone when wet which clearly requires constant attention and careful maintenance to protect the stone from direct action by the traffic during the monsoons

As a corollary the Committee remarked that the possibility of developing the Chikravapuram quarry might well be further investigated

(9) The Committee further decided that, if possible, its next meeting should be held at Madras as Members would welcome an opportunity of personal inspection and discussion of this important experiment with local officers

Item 3 *To consider Mr A K Datta's proposals for certain tests to be carried out at the Test House and on the Test Track* Mr. Datta's proposals fall under the following heads —

(1) *Substitution of bonded brick and boulder concrete roads for thick cement concrete roads for the sake of economy* The Committee

considered that in view of recent developments of thin concrete crusts on sound waterbound macadam bases, Mr Datta's proposal had no application to that case which is at present the most common in which cement concrete is being used

As regards laying of boulder concrete on an earth subgrade, Mr Murrell stated that in his opinion the volume of plums used could not exceed 10 per cent of the total volume and that therefore the saving was negligible in proportion to the difficulties Mr Syed Arifuddin also remarked that he had found great difficulty in consolidating the boulder plums into the subgrade before laying the concrete and that failing such consolidation the boulders were liable to rock and lead to failures

As regards brick bonded concrete Mr Dunbar reported that a length had been laid in Baroda State at Navsari and, he believed on an earth subgrade The Committee decided to ask for particulars* of that experiment

(2) *Application of weak cement concrete hardened at the surface* The Committee considered that, for reasons above-stated, shaded concrete would have no application in the case of slabs laid over old macadam. As regards this specification laid over an earth subgrade Mr Stein promised to furnish information in due course about the behaviour of a section recently laid on the Ranaghat Joguli road Careful records of cost and specifications had been kept and when some records of behaviour were available particulars will be supplied to the Congress

In this connection Mr Murrell mentioned the question of rolled concrete and the Committee decided after some discussion that there were other more important matters to be pursued at present It was generally agreed that rolled concrete does not give a good riding surface and is more suitable for the foundation of a two coat concrete road or in the case of a road to be covered with some black top

(3) *Application of silica cement and village cement* The Committee considered the note by Mr Chowdhary which is reproduced at Annex B page 217 and decided that the quality of village cement must necessarily vary according to the quality of the local clay and that no centralised experiments with selected materials were likely to give any valuable indication as to the possibilities of manufacturing village cement at different places The Committee was further of the opinion that any form of road surface is in India subjected to extremely hard and intense wear and that the variable nature of village cement would render it unreliable for use in a wearing surface whereas as a foundation it might not have any definite advantage over weak cement or even rammed lime concrete

As regards silica cement the Committee felt that the use of this would open the door to the adulteration of cement by the addition of silicious material and were not convinced that the manufacture of this material which is used in other countries

*These particulars have since been received and are reproduced at Annex VII pages 233 and 234

mainly for marine purposes would be likely to contribute to the advance of road construction

(4) *Application of Bamboo strip reinforcement* —The Committee did not consider this matter which would require elaborate treatment of bamboo to render it impervious to water and free from volume changes to be worth pursuing

(5) *Application of puzzolana molasses lime concrete to road construction* —The Committee did not consider that lime concrete in any form would furnish a suitable all purposes road surface and were not prepared to recommend any investigation

Item 4 —*To consider an amendment to the Standard Specification* for sizes of stones vide memorandum at Annex C page 219* —It was pointed out that the normal method of screening stone on road work was by inclined screens A grading analysis made on such screens would depend considerably on personal element and the thoroughness with which the screening was carried out The Committee decided that any standardization must be based on ordinary small scale sieving through a hand sieve shaken generally horizontally and that this should be clearly stated After considerable discuss on the Committee further decided not to record any recommendation regarding the correlation of the standard sizes determined by this method and the results obtained from road side screening on inclined screens

(2) The Committee were unanimously of the opinion that standardization of stone sizes in India is essential for the purposes of definition so that all members of the Congress would refer to and understand references to stone sizes by a standard definition In attempting however to extend this elementary requirement to a standard specification including tolerances as to maximum length and minimum thickness difficulties at once arise since any specifications which would result in the rejection of aggregates at present being used and successfully used (not so much on merits as in an attempt at standardization) would be ignored and be useless

Subject therefore to further examination by the Committee at its next meeting and to tests to be carried out on samples in actual use both by the Test House and on works elsewhere by local officers it was suggested that the following additions to the Congress specification be considered —

(a) The definition of sand should be deleted and the lower limit for $\frac{1}{4}$ inch standard size chip be changed from $\frac{1}{10}$ inch to $\frac{1}{8}$ inch

(b) For all sizes not more than 20 per cent shall exceed in its greatest length $1\frac{1}{2}$ times the nominal size and no stone shall exceed in its greatest length twice the nominal size

(c) No stone shall be less along its shortest dimension for a width exceeding one third of the length or width measured at right angles to the shortest dimension than 0 4 times the nominal size

* *Vide* pages 1 6 and 1[illegible] Proceedings of the Indian Roads Congress Vol II

(*d*) The following Table of Comparison of round and square meshes to be added to the definitions for the purpose of reference

Circular openings which correspond closely to square screen are given below —

Size of square screen as specified	Size of circular screen corresponding approximately to sq screen specified
7/8 inch	1 inch
3/4 inch	7/8 inch
5/8 inch	3/4 inch
1/2 inch	5/8 inch
3/8 inch	1/2 inch
1/4 inch	5/16 inch
3/16 inch	1/4 inch

NOTE —These definitions will require very careful consideration and wording The foregoing purports to express the intention of the Committee

Item 5 *Considered Mr Murrell s Report on trial use of primers vide Annex E page 221*

(1) The Committee expressed their appreciation of the promptness with which Mr Murrell had carried out this investigation and expressed the opinion that the use of primers was likely to be most beneficial They noted that Mr Murrell intended to construct nine miles of cold primed surface treatment and suggested that much useful information would possibly be obtained if Mr Murrell were to lay as a control check on his different specifications and in different places throughout this length a number of short lengths using the binder without primer to the heretofore accepted specification with careful records It was also decided to try out these primers on the Test Track

(2) The Committee accepted Mr Murrell s further suggestion (Annex D page 220), that the Congress standard nomenclature should be further extended to include definitions of many more terms now in common use in road work Mr Murrell will make suggestions accordingly for reference to the Committee by correspondence

Item 6 *Test Track* The Committee recommended as follows —

(1) The work on the Test Track should be continued

(2) The difficulties in testing on the track surface treatments which rely in practice on completion by the ironing effects of distributed traffic are much greater than those with other specifications which are finished by rolling Nevertheless the tests previously made*—the object of which is to determine the relative behaviour of different types of chips with different types of binder—should be repeated with the following modifications

(*a*) To start with the tests should be run with one cart of each set on the bullock cart type wheels and the other on pneumatic bullock cart tyres The bullock cart wheels

* *Vide* Specifications pages 20 to 23 of Appendix I Proceedings of the Indian Roads Congress Vol V

mainly for marine purposes would be likely to contribute to the advance of road construction

(4) *Application of Bamboo strip reinforcement* —The Committee did not consider this matter which would require elaborate treatment of bamboo to render it impervious to water and free from volume changes to be worth pursuing

(5) *Application of puzzolana molasses lime concrete to road construction* —The Committee did not consider that lime concrete in any form would furnish a suitable all purposes road surface and were not prepared to recommend any investigation

Item 4 —*To consider an amendment to the Standard Specification* for sizes of stones vide memorandum at Annex C page 219* —It was pointed out that the normal method of screening stone on road work was by inclined screens A grading analysis made on such screens would depend considerably on personal element and the thoroughness with which the screening was carried out The Committee decided that any standardization must be based on ordinary small scale sieving through a hand sieve shaken generally horizontally and that this should be clearly stated After considerable discussion the Committee further decided not to record any recommendation regarding the correlation of the standard sizes determined by this method and the results obtained from road side screening on inclined screens

(2) The Committee were unanimously of the opinion that standardization of stone sizes in India is essential for the purposes of definition so that all members of the Congress would refer to and understand references to stone sizes by a standard definition In attempting however to extend this elementary requirement to a standard specification including tolerances as to maximum length and minimum thickness difficulties at once arise since any specifications which would result in the rejection of aggregates at present being used and successfully used (not so much on merits as in an attempt at standardization) would be ignored and be useless

Subject therefore to further examination by the Committee at its next meeting and to tests to be carried out on samples in actual use both by the Test House and on works elsewhere by local officers it was suggested that the following additions to the Congress specification be considered —

(a) The definition of sand should be deleted and the lower limit for $\frac{1}{4}$ inch standard size chip be changed from $\frac{1}{10}$ inch to $\frac{1}{8}$ inch

(b) For all sizes not more than 20 per cent shall exceed in its greatest length $1\frac{1}{2}$ times the nominal size and no stone shall exceed in its greatest length twice the nominal size

(c) No stone shall be less along its shortest dimension for a width exceeding one third of the length or width measured at right angles to the shortest dimension than 0 4 times the nominal size

* Vide pages 170 and 17 Proceedings of the Indian Roads Congress, Vol II

ANNEX (1) A

Brief Note on Experimental Surfacings laid on the Great Northern Trunk Road, Madras from M 4/5 600 to M 12/0

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1 *Object of the Scheme* —No reliable data as to the wearing qualities, first cost and cost of maintenance being available for the improved types of road surfaces previously laid in this Presidency, these experiments were carried out locally to have a reliable and comparable data

2 *Selection of Road* —The Great Northern Trunk Road from M 4/5 600 to M 12/0 that was selected though maintained previously at a cost of about Rs 2 200 per mile was not up to the traffic requirements of about 1400 tons per 24 hours

3 *Cost and how Financed* —The scheme cost Rs 2 30 500/ Half the cost was met from the share of the Government of India and half from the share of the Madras Government in the Central Road Fund

4 *Location and Particulars of surfacings* —*Chart R D No 18/38 shows the particulars of the different types of surfacings laid

5 *Binder interests represented* —The work was divided into four sections represented by the firms supplying the binder as mentioned below and was carried out under the joint supervision of the Public Works Department and the Road Engineers of the corresponding firms

1 Socony Cut back Section—The Standard Vacuum Oil Co Contractors—V R Ranade & Sons Ltd

2 Shalimar Tar Section—Shalimar Tar Products (1935) Ltd Contractors—The Wardle Engineering Co Ltd

3 Burmah Shell Asphalt Section—Burmah Shell Oil Company Contractors—McKenzies Ltd

4 Concrete Section—The Concrete Association of India Ltd Contractors—Gannon Dunkerley and Co Ltd

6 *Preliminary work and alignment* —The metal crust and foundations were first examined by cutting trenches across the road for half width alternately and the following depths of new sub grade were decided on and provided —

(*a*) 4½" depth of metal for surface dressing

(*b*) 3" depth of metal for bituminous carpets (1½ to 3 thick) and bonded concrete (thin concrete 2 to 2½ thick reinforced)

(*c*) 1½" depth of metal for all the remaining cement concrete (3½ to 6") surfacings

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* Not reproduced

The 3 asphalt carpet laid over the bridge at M 10/7 was directly laid on the Reinforced Concrete Deck

The longitudinal and cross sections were first taken to enable the surface being made up to specified gradients and levels but during execu tion this was found costly and difficult to adopt The surfacings generally followed the existing contour finished true to a straight edge about 10 feet long along the road the rise or fall not exceeding 1/4 in 10 feet

The orig nal waterbound macadam not being straight in straight reaches and not curved in bends the alignment of the new surfacing was set out neatly and the foundations and subgrade made up as neces sary with extra metal

7 *Width and nature of sub grade*

(*a*) For surface dressings 23 0" width was generally adopted the idea being that the 1 6 extra on their side of the 20 wide surface would serve to prevent the edges breaking off

(*b*) For bituminous carpets, the subgrade was 20 feet and carpets also 20 feet wide

(*c*) For concrete the subgrade was made 21 feet and the pavement 20 feet the extra 6 on either side serving as a base for forms

The subgrade in all cases was first class granite metal waterbound macadam blinded with gravel slurry The subgrade except in places where Cement Concrete sand insulated was provided was ironed out under traffic for 4 to 6 weeks for effective consolidation

8 *Camber of Subgrade and Surface* The camber of the subgrade was generally the same as the surface except where varying thickness of surfacings were required The different cambers adopted are described in *Chart R D No 18/36 and connected drawings*

9 *Particulars and Cost of Surfacings* *Chart P N No 22 1940 read with *Chart R D No 18/38 furnishes full particulars regarding

(*a*) Location length width and area

(*b*) Depth of subgrade

(*c*) Type of surfacings and section

(*d*) Date of commencement and completion

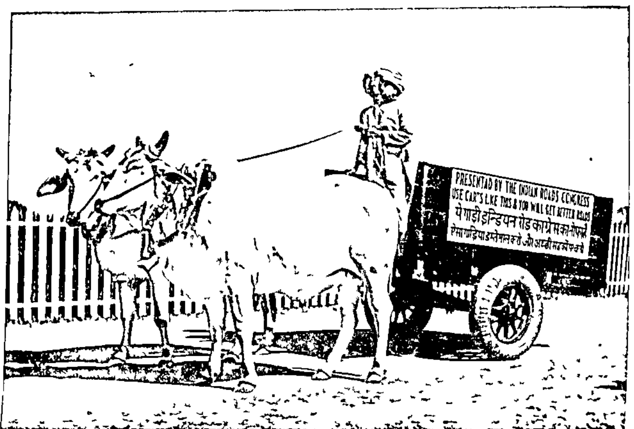
(*e*) Materials used

(*f*) Actual cost per 100 sq ft with and without leads

(*g*) Average volume and intensity of traffic per 24 hours from April to September 1938

(*h*) Remarks regarding the present condition and repairs carried out etc

* Not reproduced



Presented by the Indian Roads Congress as first prize for the best pair of Bullocks exhibited at the First All India Cattle Show Delhi 1941 to Phoolo Shah of [illegible] Rohtak District for class II Hariana pair of Bullocks.



[illegible] second prize for the second best pair of Bullocks exhibited at the last [illegible] Fair, to His Highness the Maharaja Sahib of Bharatpur for class (?) Nagori Pair of Bullocks

Detailed Remarks

10 (i) *Socony Cut back Section* M 4/5 600 to M 5/1 and M 13 0 to M 13/2

The following cut backs were used —

(1) Liquid Asphalt No 2 } For surface dressing
(2) Socofix
(3) Socofalt } For carpet

The surfacings laid from M 4/5 600 to M 5/1 both surface dressing and 1" Carpet over granite metal subgrade have failed Proposals are in hand to relay this portion with 2 to 2½" thick asphalt carpets

The surfacings laid from M 13/0 to M 13/2 over laterite subgrade using the above cut back having proved a total failure the reach from 13 0 to 13/2 has been handed back to District Board

(ii) *Shalimar Tar Section*

M 5 1 to M 5/3 M 6/4 to M 7/0 M 8/3 to M 8/7 Left half M 9/5 to M 10/5 and M 11 4 to M 11 6

The following tars were used (Heated to 250° to 270° F)

Road Tar No 1 For surface dressing first coat and grouting
Road Tar No 2 For surface dressing second coat

Road Tar No 3
Road Tar No 3 A } For carpets and sealing
Hivis Road Tar
Coal Tar Pitch For grouting

The two coat surface dressings from M 5 1 to M 5/3 and M 11/4 to M 11/6 having worn considerably are being repaired by patching the pot holes and deep ruts with premixed metal and sand and providing a wearing course of Hivis Tar at 22 lbs per 100 sq ft blinded with sand and chips

The 2 Tar crete Carpet from M 6 4 to M 6 6 has been repaired with a seal coat of Tar No 3 A at 20 lbs per 100 sq ft blinded with sand

The 2½" 1½ and 2" Tar Macadams from M 6 6 to M 7 0 M 8/3 to M 8/5 and M 9 7 to M 10 1 respectively require patch repairs and materials have been collected and repairs are in progress

The two coat Tar Surface Dressings from M 8/5 to M 8/5 482 and

M 8/6 to M 8/7, left half, have developed pot holes in wheel tracks Arrangements have been made to repair these also

The Tar Pitch grout from M 9/3 to M 9/7 is not so durable as it originally appeared to be Arrangements have been made to patch repair this surface also

The excess wear in Tar Carpets is due to the low attritive value of the Pallavaram stone, which does not wear in Asphalt carpets and concrete

(iii) *Burmah Shell Asphalt Section*

M 5/3 to M 6/4 M 8/1 to M 8/3, Left half, M 9/1 to M 9/5, M 10/3 to M 10/7 165 and M 11/6 to M 12/0

The following binders were used —

Mexphalte 10/20	For Hotmix
20/30	For Grouting
Shelmac B S	For Shelcrete Shelsheet and Shelmacadam
Colas	For Armour coat Surface Dressing and Sealing
Colas Mix A	For Colasmix A Premix
Spramex 80/100	For Surface Dressing and Sealing
Shell Primer No 1	For Surface Dressing
Shelmac S 110/150	For Sealing

The Hotmix asphaltic concrete from M 5/3 to M 5/4 is standing very well and is the best asphalt surface laid The costly plant required for this work makes it difficult to use this type except close to cities

½" and 2" Shelcrete from M 5/4 to M 6/4 Partly due to excess of asphalt and the bad weather during execution wheel tracks and depressions had developed These have been repaired by cutting and re using the old materials adding necessary aggregates to utilise the excess asphalt The surface after repairs is in a fair condition

½" Colas Armour coat from M 9/1 to M 9/5 This surface though having the facility of using the emulsion in a cold state avoiding extensive plants is not as durable as the 1½" Shelsheet and costs more Repairs are being carried out to depressions and pot holes

3" Shelmacadam from M 10/3 to M 10/6 250 This is the best macadam laid.

3" Mexphalte grout and 3" Colasmix "A" Premix over bridge and its approaches from M 10/6 250 to M 10/7 163 These carpets are standing well

Spramex Surface Dressing on Primer from M 11/6 to M 11/7 No advantage by using a primer, the surface being inferior to single coat surface dressing This surface has been patch repaired

Spramex Surface Dressing Single coat, from M. 11 7 to M 11 [illegible] The best surface dressing laid on the road, though [illegible]

Edging for Asphalt and Tar Carpets All asphalt carpets have been provided with suitable granite, cement concrete or brick edgings No edging is provided for Tar Carpets. Experience shows that Tar Carpets also require edging Granite stones are the best material for edging carpets near Madras

(iv) *Combined Shalimar Tar and Burmah Shell Asphalt Section*

M. 8/7 to M 9/1 Left half The two coat surface dressings, first coat with Tar and second coat with Spramex or Colas, though better than two-coat Tar Surface Dressings, are not very satisfactory

(v) *Concrete Section M 7/0 to 8/1, M 8/7 to 9 1, Right half, and M 10/7 165 to M 11/4* Nilgiri and Shahbad rapid hardening cements have been used for the pavements

All concrete surfacings are standing well, except the rolled concrete from M 7/2 to 7/3 330 which is wavy

No appreciable difference is seen between Nilgiri ordinary cement and Shahbad rapid hardening cement pavements

The cement macadam surface from M 11/3 to 11/4 is not as uniform as the cement concrete surface hand tamped

No difference is seen in behaviour between cement concrete base bonded and cement concrete sand insulated

11 *Metal berms* Metal berm, 5′ 0″ wide generally, on either side of surface has been provided to protect the edge of the surfacing and serve as a useful addition to the road width for occasional use

12 *Maintenance of records* The works were commenced on 1-7 37 and completed by about the middle of May 1938 The surfaces were maintained by the respective contractors till the middle of November 1938 when they were handed over to the Department for maintenance till 31 3 1943 Full records of experiments are being kept in the standard form recommended by the Indian Roads Congress The condition and behaviour of the surfacings, their maintenance with details and costs, particulars of traffic and other details will duly be recorded till March 1943, for comparing properly the merits of the different types and deciding which of them are suitable, considering their first cost and cost of maintenance

NOTE BY MR T CAMPBELL-GRAY

Summarised Notes on Experimental Seal Coats with Shalimar Tar after 9 months service.

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1 These experimental surfaces were laid in March 1939 with the permission of the Madras Public Works Department at Mile 6 6 where the adjoining surfaces were 2" Tarcrete and 2½" Tar Premix Carpet Reference to plan attached, page 212, will furnish complete details of each experiment

The cause of the unsatisfactory behaviour of the wearing course on certain tar sections, particularly those surface-dressed, having been examined constructively in detail, the purpose of the experiments was to investigate the behaviour of surfacings laid to specifications considered more likely to suit the local aggregates and existing conditions

2 The experimental stretches were 12 in number and comprised of the following —

(a) *Premixed Sand Seal*

With and without spot priming

Unit quantity of tar for premixing sand varied

Five Experiments —'A', 'B', 'C', 'L', and 'M'

(b) *Liquid Seal—Tar Sand and Tar Chip Sand*

Two Experiments —'D' and 'E'

(c) *Tar Mats—(Thin Tarcrete)*

Spot priming with varying unit quantity of tar,

Grading of chips also varied

Five Experiments —'F', 'G', 'H', 'J' and 'K'

See page 212 for full Specifications

3. *Results established at date.*

(i) There appears to be a marked advantage in using High Viscosity (Hivis) Tar for surfacings, over other grades

(ii) Spot priming with Hivis at not less than 6 lbs per 100 sq ft followed by premixed chips and sand, produces an excellent wearing course with the local aggregates which on Heavy and Light Traffic sides shows no wear at date

(iii) Specification 'F' is considered the most satisfactory The surface is mosaic but if a still smoother finish is required, other experiments indicate a slight increase in the unit quantity of spot priming will give this

(iv) Specifications 'G', 'H' and 'J' are also quite satisfactory at date as might be expected on account of their close similarity to Specification 'I' whilst Specification K shows clearly by the surplus tar on surface and uneven wear that 18 lbs tar per 100 sq ft for spot priming is too much

(v) The Tar Sand Seal (Specification D) is exactly the same as given to the 2 furlongs of 2" Tarcrete and whilst satisfactory it must be borne in mind its application is limited as it gives no facility to rectify unevenness in the road surface

4 *Reasons attributed for successful results obtained* —

Hivis Tar was not used for any of the wearing courses of the original surfaces because at the time these experimental surfaces were laid its suitability during a Madras hot weather had not been established Since, it has been found that even when used for a liquid seal with sand or sand and chips it has given good results

The excessive wear on the second coat of the tar surface dressed sections was undoubtedly mainly due to the chips having crushed badly and the provision of cushioning by means of mixing sand with chips as has been done in the present experiments and as recommended by the General Manager to this Company (Col G E Sopwith s Note* on Great Northern Trunk Road Experiments—Shalimar Tar Section—of 9th February 1939) has definitely proved advantageous

It may be argued that the period the present experimental surfacings have been under traffic is insufficient to draw conclusions but it must be recollected that the original wearing courses on the surface dressed sections are reported to have shown excessive wear within a short time of laying The small areas constituting the experiments may also be considered insufficient to permit of reasonable judgment being made but from the knowledge gained of the behaviour of the original surfacings on the Great Northern Trunk Road and from results obtained since to Specifications revised on the basis of that knowledge and applied elsewhere we believe the results so far obtained will be maintained and we recommend with confidence that a wearing course to Specification 'I' with possible slight variations to suit local conditions will restore the surface of the tar sections and provide a lasting wearing mat

*Not reproduced

Experimental Seal Coats with Shalimar Tar—Laid March 1939
Traffic allowed—1 to 2 days after completion

G Tar Mat
Spot Prime Hivis at 4 lbs per % sft ¾ to ⅛ chips premixed with Hivis at 4 lbs per cft Sand premixed at 7 lbs per cft Spread at 6 cft per % sft Consolidated

H Tar Mat
Same as above but 10% lime filler added by volume

J Tar Mat
Spot Prime Hivis at 4 lbs per % sft ¼ to 1/16 chips premixed with Hivis at 4 lbs per cft Sand with lime filler premixed with Hivis at 7 lbs per cft Spread at 2½ cft chips 1½ cft sand and ½ cft lime per % sft

K Tar Mat
Spot Prime Hivis at 18 lbs per % sft ¾ to ¼ chips pre mixed with Hivis at 4 lbs per cft. and sand at 7 lbs per cft 4 cft premixed aggregate spread per % sft Consolidated

L Premixed Sand
Spot Prime Hivis at 4 lbs per % sft Sand premixed with Hivis at 7 lbs per cft and spread at 4 cft. per % sft Consolidated

M Premixed Sand
Spot Prime Hivis at 4 lbs per % sft Sand with 10% shell lime (by volume) pre mixed with Hivis at 7 lbs per cft and spread at 4 cft % sft Consolidated

To Nellore	North
7 feet — G Tar Mat	F Tar Mat — 21 feet
4 feet — H Tar Mat	
6 feet — J Tar Mat	E Tar Chip Sand — 22 feet
21 feet — K Tar Mat	
12 feet — L Premixed Sand	D Tar Sand — 26 feet
10 feet — M Premixed Sand	C Premixed Sand — 20 feet
	B Premixed Sand — 18 feet
	A Premixed sand — 14 feet
From Madras	South

F Tar Mat
Spot Prime Hivis at 4 to 6 lbs per % sft ¾ to ¼ chips premixed with Hivis at 3½ lbs per cft Sand premixed at 6 lbs 4 cft chips and 2 cft sand spread per % sft Consolidated Finished with pre mixed sand at 4 cft per % sft

E Tar Chip-Sand
Hivis poured at 20 to 22 lbs per % sft 1½ cft chips and 1½ cft sand spread per 100 sft

D Tar-Sand
Hivis poured at 20 to 22 lbs per % sft Sand spread at 3 cft per % sft

C Premixed Sand
Sand premixed with Hivis at 3 lbs per cft and spread at 4 cft per % sft No priming Coat

B Premixed Sand
Sand premixed with Hivis at 7 lbs per cft and spread at 4 cft per % sft

A Premixed Sand
Sand premixed with Hivis at 6 lbs per cft and spread at 4 cft per % sft No priming coat

Note —The roller used for the above experiments was a one ton hand roller

NOTE BY COLONEL G. E SOPWITH

Great Northern Trunk Road Experiments

(1) *Suggestions in 1939* In a Note dated 8th February 1939, written after an inspection of the various experimental Road Tar Sections, I set forth my personal views on the causes of partial failure of certain sections and the action which I considered would correct them

The three methods I advocated were —

(a) Sand and chips (instead of chips only)

(b) Liquid Seal with sand blinding

(c) Pre mixed sand mat

The last named I wished done on a very small scale as an experiment pure and simple It was not successful since it rolled up under traffic I am not satisfied that a modified specification for this type of work would not be successful but in view of results, the Great Northern Trunk Road in present circumstances is not the place on which to continue experiments

The other two suggestions, however, came very much into practical consideration The idea of chips and sand was to create cushioning as a guard against the obvious attrition and abrasion that was going on

I expressed my opinion that, since attrition and abrasion appeared to be the greatest evils, the best solution of all was the application of a liquid seal with sand blinding to protect completely the surface of stone and chips from direct contact with the iron tyres of bullock carts

The objection made to this was that some of the surfaces were not then even-riding and that sand alone would not level them up I, therefore, advised a trial with both methods and was under the impression that it was agreed that, after visual examination of results for a month or two, the whole of those portions of the road surface which were showing stone or chip wear, would have a chip and sand or a liquid seal and sand treatment, as results of experiments might determine, applied and that any further surfaces, that might later on show wear of this type, would be similarly treated

On inspecting the road in March 1940, I found however, that, though the experiments as suggested were carried out in March 1939 over a total length of 60 feet on one half and of 121 feet on the other half (*vide* page 212), nothing beyond patch repairs had been done to the section surfaces as a whole

It is definitely unfortunate that I misunderstood the intention, as I expected, when re-visiting the road, to find the whole surface treated, whereas naturally much deterioration has also occurred in lesser or greater degree on certain other sections making the problem of overcoming the defects now more difficult and more expensive

Experimental Seal Coats with Shalimar Tar—I and March 1939
Traffic allowed—1 to 2 days after completion

G Tar Mat

Spot Prime Hivis at 4 lbs per % sft ¾ to ⅛ chips premixed with Hivis at 4 lbs per cft Sand premixed at 7 lbs per cft Spread at 6 cft per % sft Consolidated

H Tar Mat

Same as above but 10% lime filler added by volume

J Tar Mat

Spot Prime Hivis at 4 lbs per % sft ¼ to 1/16 chips premixed with Hivis at 4 lbs per cft Sand with lime filler premixed with Hivis at 7 lbs per cft Spread at 2½ cft chips 1½ cft sand and ¼ cft lime per % sft

K Tar Mat

Spot Prime Hivis at 18 lbs per % sft ¾ to ¼ chips premixed with Hivis at 4 lbs per cft and sand at 7 lbs per cft 4 cft premixed aggregate spread per % sft Consolidated

L Premixed Sand

Spot Prime Hivis at 4 lbs per % sft Sand premixed with Hivis at 7 lbs per cft and spread at 4 cft per % *sft Consolidated*

M Premixed Sand

Spot Prime Hivis at 4 lbs per % sft Sand with 10% shell lime (by volume) premixed with Hivis at 7 lbs per cft and spread at 4 cft % sft Consolidated

To Nellore	North
G Tar Mat — 7 feet	F Tar Mat — 21 feet
H Tar Mat — 4 feet	
J Tar Mat — 6 feet	E Tar Chip Sand — 22 feet
K Tar Mat — 21 feet	
L Premixed Sand — 12 feet	D Tar Sand — 26 feet
M Premixed Sand — 10 feet	C Premixed Sand — 20 feet
	B Premixed Sand — 18 feet
	A Premixed sand — 14 feet
From Madras	South

F Tar Mat

Spot Prime Hivis at 4 to 6 lbs per % sft ¾ to ½ chips premixed with Hivis at 3½ lbs per cft Sand *premixed at 6 lbs 4 cft* chips and 2 cft sand spread per % sft Consolidated Finished with *premixed sand at ¼ cft per* % sft

E Tar Chip Sand

Hivis poured at 20 to 22 lbs per % sft 1½ cft chips and 1½ cft sand spread per 100 sft

D Tar-Sand

Hivis poured at 20 to 22 lbs per % sft Sand spread at 3 cft per % sft

C Premixed Sand

Sand premixed with Hivis at 3 lbs per cft and spread at 4 cft per % sft No priming Coat

B Premixed Sand

Sand premixed with Hivis *at 7 lbs per cft and spread* at 4 cft per % sft

A Premixed Sand

Sand premixed with Hivis at 6 lbs per cft and spread at 4 cft per % sft No priming coat

Note—The roller used for the above experiments was a one ton hand roller

NOTE BY COLONEL G F SOPWITH

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It is definitely unfortunate that I misunderstood the intention as I expected when re visiting the road to find the whole surface treated whereas naturally much deterioration has also occurred in lesser or greater degree on certain other sections making the problem of overcoming the defects now more difficult and more expensive

(2) *Causes of partial failure* Before discussing remedies I should like to give my views on causes They must necessarily be to some extent hypothetical as certain data are indefinite

(i) As regards surface treatment, the climatic conditions at the time were abnormal and very wet I understand that the time factor was regarded as pressing but this is no excuse for us if we allowed such work to proceed before the road was thoroughly dried out If this was a fact, sufficient penetration would not take place, the first coat instead of binding the crust into a solid mass would form little more than a film on the surface and the waterbound metal below would, under the heavy traffic, almost certainly be free to move and to disintegrate and lose mechanical interlock The surface would then break, dust get in and serious rutting occur Such rutting certainly occurred in mile 5 and the suggestion here given may be the explanation

Be that as it may, it was visually obvious in February 1939 that the chips of the second coat and many of those of the first coat in the traffic lanes had crushed into sand, in other words, the chips needed support and protection against this tendency

(ii) As regards carpets I am of opinion that the specifications should have been modified I am not using this as an excuse but as one probable reason for any partial failure that has occurred and solely in order to clarify the position and so to see the best way to effect remedies When the draft specifications were made out, I understood wrongly as it turned out that the stone was of excellent quality and not brittle or unduly subject to abrasion or attrition

Had I fully realised its real characteristics, I should have included filler in the premixing of the main body, sand with chips for the topping and a liquid seal with sand for the final surface treatment

But more serious than that is the probability that wrong temperatures were at times worked to and that the mixing was not as scientific as it might have been Improvised apparatus instead of mechanical mixer was used and this led to a want of uniformity in batches of mix I am informed that on one occasion at least, the contractor was not only heating the aggregate before heating the Tar, but pouring the Tar in cold on to the heated aggregate and then heating for 20 minutes or more to get a thorough coating As this occurred with high viscosity Tar, the result could not be satisfactory, and if it occurred often, it would account for many unsatisfactory signs which I found in disintegrated portions and in sections cut out of the road

This seems to indicate that mechanical mixers are very desirable for large works of this type

(3) *Remedies* Turning to remedies for the existing state of affairs, the difficulties have, as already stated, been greatly increased by large scale action not having been done before the last monsoon

It is an axiom both with surface treatment and carpets that immediate action when repair to even the smallest area is visually necessary should be taken Failure to do this certainly as far as thin carpets are concerned may lead to fairly rapid deterioration and even eventually to breaking up and the loss of the whole investment

Ruts and pot holes are the first items to deal with and these I found were being repaired correctly with premixed chips and sand This having been done there remains the general surface itself Mr Campbell Gray advocates a spot prime coat with pre mixed chips and sand (Specification F *vide* his note)

I agree after inspection that the result has proved satisfactory after 12 months wear (it was laid in March 1939) but I noticed that the chips were definitely if slightly abrading and am sure that to get a lasting result a liquid seal with sand should also be applied

This is obviously expensive I think however in such experiments that what is required is a solution for the future regardless of comparative costs If a solution is found it is easy to calculate what the cost would be were the work to be carried out *de novo* to a specification which would incorporate the methods proved successful and the cost of which would obviously be considerably less than that of a carpet completed to a specification faulty in the local conditions prevailing plus what amounts to an additional thin carpet

If the surface of the road after filling the ruts and pot holes is sufficiently even then I consider that a liquid seal with sand blinding should be applied over the *whole* surface one fortnight after completion of the patch repairs and I believe that to be the solution

If the surface is not sufficiently even then there appears no alternative to applying sand and chips to even up and subsequently a liquid seal with sand That I believe to be the solution and I shall be surprised if any further treatment is necessary before the end of the period of observation in March 1943

I would however emphasize that I consider that whatever is done should be done now to prevent further deterioration

(4) *Grade of Tar for final surfacing* A point of great importance is the grade of Tar to be used Mr Campbell Gray is in favour of Hivis for surface treatment in the climatic conditions of Madras I do not feel so confident as its composition lends itself to the possible eventual development of brittleness if in direct contact with the air and I personally advise Road Tar No 3 A Whether if chips and sand are used Hivis could be confidently used with safety assuming it not to be covered by a liquid seal I should like Mr Fielder to give his opinion on (For the stone used on the Great Northern Trunk Road I have in these Notes given my definite view that a liquid seal should be given and it should be with Road Tar No 3 A)

(5) *Points in Annex A, page 205, placed before the Committee* —There are one or two points which I wish to refer to

On page 207, Coal Tar Pitch is named as the material for Grouting The material is actually Pitch plus Tar This is of importance, as some engineer through misunderstanding, might order Pitch alone and endeavour to carry out work with it with disastrous results both for him and the manufacturer (This has actually occurred in the past on several occasions, because the Indian Stores Department, until I got them to alter the wording, used to put down in their contracts "Coal Tar Pitch for roads")

At the bottom of page 208, it is stated that "Tar Carpets also require edging This is a fact but personally I am against stone sets, concrete or brick edging as it is very difficult to ensure that the top of the edging will always be at the level of or below the surface of the edge of the carpet If it is not, water will collect and, if it does not do great harm, it certainly is not an advantage If there is sound ground on which to bottom it, I prefer for Tar Carpets, a buttressed shoulder, with an outer slope of 45°, which is intimately incorporated with the mass of the carpet itself and which from long experience *I know to be completely satisfactory*

(6) *General remarks* —In conclusion, I should like to say that this Note has been written in an honest endeavour to find causes and remedies *In my opinion, there have been mistakes in specifications* and in methods and no effort to conceal them, as this Note proves, has been made Without the most intensive thought on every aspect, it is impossible to produce not only the remedies for present application but a specification which will not require such remedies for, failures, complete or partial, are due in 99 cases out of 100 to fault in methods of construction or application and not to the material itself Each one of the specifications used on the Great Northern Trunk Road have proved successful elsewhere and clearly, modification of the specifications to suit local material and climatic conditions is all that is necessary to ensure equal success in Madras

Sections of the carpets and other samples are being obtained from Madras for Mr Fielder to examine and analyse If they arrive in time, Mr Fielder will no doubt be able to give the Sub Committee more scientific views than mine on causes

ANNEX (I) B.

Notes by Dr A N Choudhary on a paper read by Mr Datta regarding "Village Cement" and "High Silica Cement" at the Sixth meeting of the Indian Roads Congress Bombay, 1939*

Two kinds of cements are described in Mr. Datta's paper One of these he calls "Village Cement" and the other he calls "High Silica Portland Cement".

My comments on these two cements are given below —

Village Cement

The method of manufacturing "Village Cement", as described by Mr Datta is not a new one This method was used in England by General Sir C Pasley for manufacturing a hydraulic cement from the blue alluvial clay from the river Medway near Chatham In India, a cheap cement was sought to be manufactured for use in connection with the construction of the Lloyd Barrage by a similar process but was found to be unsatisfactory A cement similarly manufactured and designated "Thistle Brand cement came into the Indian market some years ago, this cement was brown in colour and was for all practical purposes an artificial hydraulic lime having similar physical properties

The chief drawback of burning such a cement at any required site would be the unknown characteristics of the clay and the quality of the lime that would be locally available

Moreover, manufacture would have to be carried out under crude and uncontrolled conditions with the assistance of inexperienced staff The result will be the production of cements which will be so un uniform in quality as to be thoroughly unreliable for use in any engineering work In this connection it has to be remembered that the CaO and the MgO contents of different limes vary widely and that there is an optimum temperature for brushing each clay in order to develop its best puzzolanic properties, when mixed with lime As much care, skill and technical work would be necessary to produce a reliable cement of the kind described above as in the case of ordinary Portland cement Such cement cannot, therefore, be produced cheaply in competition with Portland cement, where the latter is readily available at a reasonable cost

No useful purpose will be served by undertaking laboratory researches to determine the physical properties of 'Village Cement', which are known to depend on the chemical characteristics of the ingredients used and the temperature of burning, so long as Portland cement is readily available at a reasonable cost

High Silica Cement

From the description given by Mr Datta it appears that the "High Silica Cement" is nothing more or less than a Puzzolanic cement, whose characteristics have already been studied

* *Vide* Proceedings of the Indian Roads Congress Vol VI pages 1 (c) to 28 (c).

The important point about a puzzolanic cement is that, as stated by Mr Datta, the puzzolana in the cement combines with the free hydrated lime set free by the cement during setting, and forms a lime puzzolana compound its chief value lies in the fact that it has increased resistance to attacks by chemical agencies and in particular by sea water Such a cement is, therefore, more suitable for use in marine work than an ordinary Portland cement

The various test results quoted by Mr Datta at the bottom of page 5 (c) of his paper should not ordinarily be comparable, as the tests described by Scott and Granville were obviously carried out in a colder country

Moreover, such tests are usually carried out in a laboratory on mortars of dry consistencies, in which case unchanged or increased tensile strength may be obtained by substituting Portland cement by Puzzolana in small amounts The *effect of such substitution of* Portland cement by Puzzolana in small amounts on plastic mortars or concretes as ordinarily used in engineering works is to decrease the strength at the early ages though the ultimate strength may be higher Such a cement is, *therefore unsuitable for use in making roads where a cement of the* rapid hardening variety is required

The name High Silica Cement is a misnomer The figures for silica contents of cement of this type, as shown in the last two columns of the table on page 5 (c) of Mr Datta's Paper, are misleading in that they include both 'soluble' and 'insoluble' silica, the former of which only takes an active part in combining with liberated hydrate of lime during the setting of a puzzolanic cement As a matter of fact, it is believed that the activity of the puzzolana is due not only to its combination with what is known to analytical chemists as "soluble silica" but to the presence of alumina and also possible alkalies Although the total silica content of a puzzolanic cement is necessarily higher than that of an ordinary Portland cement, only a portion of this silica and other constituents of the puzzolana take an active part in giving it its characteristic qualities It is therefore, desirable to designate this material by its generally accepted name of Puzzolanic cement rather than "High Silica Cement", the name given to it by Mr Datta We may, perhaps, in this country call this cement '*Surki* cement' but I am not in favour of any change in the nomenclature to avoid confusion

ANNEX (I) C

It has been pointed out by Mr A Lakshminarayana Rao that a literal interpretation of the Standard Specifications for the sizes of broken stones as laid down by the Indian Roads Congress (*Vide* page 177 Proceedings of the Indian Roads Congress Volume II) allows long stones being supplied by contractors and these cannot be rejected if they pass the appropriate square meshes He suggests that a proviso be added to the specifications that the stones used should be fairly cubical in size

(2) In this connection a typical specification for gauges of broken stone may be quoted from the British Standard Specification—

3 inch Gauge Broken Stone

Broken stone specified as 3 inch gauge shall all pass through a 3 inch ring and shall consist of the following sizes expressed as percentages by weight —

Not more than 15 per cent passing through a 2½ inch ring in every direction

Not less than 65 per cent over 2½ inches and not exceeding 4 inches in greatest length by measurement

Not more than 20 per cent over 4 inches in greatest length by measurement

(3) The Technical Sub Committee when recommending the present Indian Roads Congress Specifications did consider the British Standard Specifications but thought that they were complicated by tolerances and not suitable for India where stone was mainly hand broken and because in actual practice square mesh sieves were used for grading stones

(4) It however appears as pointed out by Mr Rao that there is no check in the existing specifications to prevent long stones being supplied where fairly cubical ones are intended and therefore it is suggested that the following proviso be added under the said table in Volume II —

Provided that

(*a*) in the standard gauges of 2½ 2 and 1½ inches not more than 20 per cent of any sample shall exceed in its greatest length the standard size plus one inch and

(*b*) in the standard sizes 1 ¾ and ½ inch not more than 20 per cent of any sample shall exceed in its greatest length the standard size plus ½ inch

The Committee might consider whether this is too severe or lenient

ANNEX (I) D

Copy of letter No 3236 XLV M 51(1), dated Muzaffarpur, the 1st April 1940, from W L Murrell, Esquire, I S E, Superintending Engineer, North Bihar Circle, to the Secretary, Indian Roads Congress, New Delhi

I have the honour to suggest that M E Lloyd, Esquire of Messrs Standard Vacuum Oil Company, of No 6, Church Lane Calcutta be co opted for any meeting of the Technical Sub Committee held for the dis cussion of bituminous work

Mr Lloyd is really filling the place of Mr C D N Meares, a member of last year's Technical Sub Committee Both Mr Lloyd and Mr Shannon of Messrs Burmah Shell, assisted me in the primer experiments on which I submitted my report recently (*Vide* Annex E page 221)

2 I would like also to suggest that the Technical Sub Committee should draw up a glossary of terms for the guidance of members of the Indian Roads Congress

e g —

"Priming (cold)' —Treatment of a waterbound road, whether metalled gravelled, or stabilised earth, with thin binder, generally cold so that absorption is generally complete *within 24 hours The object is to* penetrate the finer materials and make them hold the larger more securely. The use of sand or other fine blotter exceptional rather than the rule Preparatory to other treatment

'Tack coat' —A thin film of binder spread over a bituminous, *portland cement or other higher type surface with* a view to providing surface adhesion for immediate further treatment Penetration is not a function *of the tack coat*

There are a good many people still ignorant of the real meaning of cut back, road oil, fluxing and cutting back oils cleaning oils binder, blinder, primer, body coat, flush seal surface treatment, premix, drag brooming, drag spreading, subgrade and so on

Such a glossary is a logical necessity in any policy of standard isation

ANNEX (I) F

SMALL SCALE

TRIALS OF COLD AND SEMI [illegible]

Extract.—" It was thought that for dusty roads [illegible] District Board roads a cold [illegible] that it would, in all cases, have the advantage [illegible] application of the main paint coat [illegible] Mr Murrell to get trials made in Chota [illegible] supplied through Messrs Shannon and [illegible] to the Technical Sub Committee "

Report

As Mr Meares who has always been a strong advocate of [illegible] was absent on war duty, and as the Standard Vacuum Oil Company was thus not represented in the supply of primers I without [illegible] the Technical Sub Committee collaborated also with Mr M E Lloyd of that Company Mr Lloyd and Mr Shannon both attended the experiment and afforded the utmost assistance

Owing to being very busy in North Bihar, I could not go to Chota Nagpur but most fortunately there happened to be an excellent road within a mile or so of my headquarters on which to make trials

The portions of the Muzaffarpur District Board roads from Muzaffarpur to Sitamarhi were metalled as a Road Development Work The metal was of Pakur stone to Indian Roads Congress size of about 1½", consolidated to a depth of 4½" on brick soling Pakur stone is evidently a gneiss very tough and hard, with no cementitious properties

Chips could therefore not be used solely for finishing

After dry rolling the metal was blinded with a 50 50 mixture of fairly fine sand and Gorpa Mooram the latter itself a mixture of weak small gravel and clay

The work was done in the monsoon of 1939 using a 10 ton steam road roller

Almost as soon as the dry weather started, the surface began to loosen and the metal began to get thrown off the road though the traffic was by no means heavy Not only would the loss of the work be serious, but the metal cost Rs 43 per 100 cubic feet and it must not be lost

So far, the District Board have been minimising the disruption of the waterbound by spreading, every few weeks, ¼" to ½" of soil (North Gangetic silt) over the waterbound metalled surface The metal is so

loose that one can move many pieces slightly between thumb and forefinger By pushing pieces of metal from above with a small screw driver, first on one end and then on the other, one can make most of the metal see-saw or rock In the tests described, this is called the 'rocking test'

This road, therefore, is quite a good example of road which is scarcely suitable for a direct surface treatment of hot tar or bitumen, and stone chips

A great thing about this investigation is that the results, if any can be arrived at should be of considerable interest to any engineer looking for an earth stabiliser for *kutcha* roads, aerodromes, etc A stabiliser of this type would have considerable recuperative properties compared with rigid stabilisers like cement

The whole series of 13 tests has been described on the chart attached to this report, page 225 Except where otherwise stated, the observations are my own

Babu Gauri Shanker Rana, Overseer of the Muzaffarpur District Board gave much assistance with the work and with later observations

We are looking for a preparation that will sink into the waterbound surface within 24 hours or so, so that no blotting with sand or other fine material will have to be done—to any extent—before the main work of surface treatment with chips, carpetting, or other work can be proceeded with

The primer must also be such that absorption of it must make the waterbound material below much tougher and more resistant to disturbance or disruption by traffic A little of the primer should remain on the upper surfaces of the pieces of metal to act as a tack coat

The prices at which Shell Experimental Cold Primer, and Shalimar Tar Primers Nos 1 and 2 could be put on the market are not yet known In no case do the firm interested divulge the recipe for any of the primers This is an unsatisfactory condition of affairs as engineers can scarcely be expected to place orders unless they are enabled to give a definite specification so that they may, if necessary, check deliveries against contract specification

General Observations as a Result of the Experiments.

(1) *Covering capacity* :—The rate of application was chosen arbitrarily Most of the application was done from a kerosine tin with the top half of one side perforated the opposite side having a handle Complete spreading was effected with brooms

It seems certain that, for the thinner primers, Shell Experimental Cold Primer, Liquid Asphalt No 2, and Socofix Primer, Tar Primer No 1, and perhaps Shell Primer No 2 and Tar Primer No 2, could be put on at between 15 to 20 lbs per 100 sq ft The lower limit is possible if moistening the dry road be done, also if the earth binder is not swept out from between the pieces of road metal too thoroughly when cleaning (not more

than what is enough to prevent the primer running off the waterbound surface owing to camber)

Moistening the surface first as in G, I, and L seemed to have no effect on the ultimate absorption and strength except in the case of the tar L, and even in this case the deleterious effect is very slight, if it does actually exist

(2) *Blotting or sanding resorted to on account of delayed absorption* — This was done only in the case of Liquid Asphalt No 2, tests G and H Subsequent observations show that Liquid Asphalt is too long in being absorbed to fulfil one of the main qualifications of a good primer

(3) *Absorption* —Quick and satisfactory results followed with Shell Experimental Cold Primer even with heavy applications, also with Socofix Primer and Tar Primer No 1

In this connection, however, it may be pointed out that the particular binder used—sand and mooram in this case—will probably have a good deal of influence There had been rain a day or two before the experiment and it may be that the clay in the mooram had not fully dried out

Further experiments are really required where chips or fines only are added during wet rolling as in Chota Nagpur Public Works Department if it is decided to give up No 1 Hot Road Tar and Sand Priming as has been in force there for a good many years The substitution of 15 to 20 lbs of cold primer for 28 32 lbs of No 1 Road Tar may lead to saving in material costs also the cost of heating and maintenance of boilers

(4) *The general appearance of the surface* —The dislodging of stones by traffic is a sign of lack of requisite toughness of the primed surface This was noticed only in sections A and B It almost seemed that the crude kerosine or whatever cut back oil was used was acting as a lubricant like water rather than as a viscous hindrance to disruption like bitumen

This is shown also in the rocking test and by the depth to which the primer crept along the surface of the metal—more than it penetrated the sand clay blinder

It is also shown in the lack of stickiness of the surface materials

This is a great pity as this is a good quick primer

(5) *Rocking test* —This is of course a very approximate criterion and one might easily be 10 % out in a comparative test Except for A and B, it gives fairly uniform results C D and M give the best results Evidently quick absorption and a good tough surface are not quite compatible

(6) *Penetration* —This also is a very approximate quantity as observed In one and the same surface the depth of penetration varies from, say, 1/4 to 1/2 inch It depends on the grouping of the metal and *sand clay binder on whether the primer lodged for a long or a short time* and on the depth of primer Observations were taken half way between the crown and the edge and what was evidently the average depth over 30 to 50 square inches was taken

(7) *Depth to which primer crept along the surface of the metal, even below the level to which the sand clay was penetrated* —This is taken as a measure of the wetting power of the primer on stone with such a smooth surface as this Pakur metal presents It will be seen that the low grade kerosine or other cut back used in A, B and to a less extent in E and F and in I and J, gives the primer high penetrating power, though whether it takes a proper share of bitumen with it to effective depths below the surface remains uncertain Evidently not much was taken to a good depth in the case of A and B, atleast The cut back oil in the tar primer, however, does not seem to act in this way

Two pieces of road metal from each section to show this creeping or *wetting action, are kept with the records*

(8) *Smell* —The low grade kerosine *in the cut back primer, and the* diesel or similar oil in the other primers using it as a flux are typical Both the Bitumen Companies are apparently using the same fluxing oil

(9) The stickiness of the tar sections is easily superior to the others, but it is really not all necessary Any of the other surfaces could receive further treatment without a tack coat

Final Conclusion

The work has been very successful For this particular type of waterbound surface it can be said, even with such small areas under observation, that Socofix Primer, Shell Experimental Cold Primer, and *Shalimar Tar Primer No. 1 are all reasonably effective primers*

Shell Primer No 2 and Shalimar Tar Primer No 2 are possible if traffic requirements allow of delay, and if the use of sand for blotting purposes is not objected to

I would like to see Liquid Asphalt No 2 on a waterbound surface with different binders

ANNEX (I) F

Minutes of a meeting held at the Government Test House Alipore on the 16th January 1940

Present

1 Mr E F G Gilmore Indian Stores Department

2 Mr N N Sen Gupta Superintendent Government Test House

3 Dr A N Chowdhary Physicist Government Test House

4 Colonel G E Sopwith C o Messrs Turner Morrison and Co Ltd

5 Mr Ian A T Shannon Burmah Shell Company Calcutta

6 Mr J A Stein Special Officer Road Fund Works Calcutta

7 Mr K G Mitchell Consulting Engineer to the Government of India (Roads)

It was decided that the work on the track should now proceed as follows —

(1) Loosen old surface between tracks spread metal to the original depth as before and consolidate

(2) Consolidate over the ruts before the paint coat is applied with 6 inch iron tread wheels of about 3 feet diameter fitted to an under carriage under two of the existing towing carts the wheels being so staggered as to sweep out a track of approximately 10 inches each The cart to be loaded to 6 000 pounds giving an intensity of pressure on the wheels of 500 pounds per inch width

(3) Apply paint coats as before but using chips only in the strips which will come under test apply say 18 inch wide over each strip Blind the rest of the paint coat with sand and brush off surplus sand and after a few days

(4) Surface up the chips and paint coat with 6 inch iron tread rollers as before starting with lighter load and gradually increasing to 500 pounds per inch width

N B —In both cases (2) and (4) in using the 6 inch iron tread wheels the carts are to be towed straight without any side throw

(5) Provide for use if possible on undercarriage 6 inch rubber tyred wheels for finals surfacing up of the tracks to be tested In this case it will probably be necessary to provide a little side throw

(6) If it is possible in time re arrange the gearing so as to lengthen the pitch of the side throw of the carts to about 40 feet

(7) Chamfer the tyres on the test carts at the edges ½ inch by ½ inch and round the edges also

ANNEX III

Proceedings of an informal meeting of the Members of the Technical Sub Committee of the Council of the Indian Roads Congress present in Calcutta, held at the Test Track on Saturday the 8th June, 1940

The Committee carefully examined the general condition of the Track which was promising of more definite results and information than was obtained from the previous tests A number of samples of the surface dressing were cut out in the presence of the Committee for subsequent extraction and sieve analysis of the mineral content The Committee further noted that

(1) the latest detailed report on all sections would shortly be ready for their information,

(2) the rainfall had been negligible throughout most of the tests up to the sixth instant when there had been a heavy shower From the beginning of the month the rubber tyres had been taken off of the test carts on both tracks and iron tyres substituted with loading of 500 pounds per inch width On or about the fourth instant, the load on the test carts had further been increased from 500 to 750 pounds per inch width and movement of the surface dressing and the formation of cracks in it had commenced With the exception of the Delhi stone, the water-bound macadam appeared, from the places where the samples of surface dressing had been cut, to be sound and not moving,

(3) owing to this cracking in the surface dressing water had penetrated after the rain on the sixth and the macadam below was definitely wet Where primers had not been used this appeared, at least with the bitumens to have somewhat broken the bond or adhesion between the main body of the stone macadam course and the surface dressing—thus probably accentuating the tendency to movement in the surface dressing The bond in the primed sections appeared to be better, but this was cancelled by the apparent shortage of binder,

(4) in the case of Delhi stone, the waterbound macadam had failed completely in several places This was attributed to—

(a) the use, owing to shortage of full size stone at site of 20 per cent of 1½ inch and 80 per cent of ¾ inch stone instead of the standard of 75 and 25 per cent respectively,

(b) excessive rolling of the waterbound macadam resulting in the rounding of the stones, and possibly

(c) the use of excess amount of *hoggin* (although a large proportion of the finer material appeared to be stone crushings)

Unprimed Sections

(5) Subject to the analysis of the samples cut out, it appeared that there was so far little to choose in the behaviour of the different binders with Pathankot and Jhansi stones. In both cases, there was an appearance of considerable dust from the crushing of the chips but no signs on opening up the surface of the binder having been overloaded with the resulting filler. In both cases, the surface dressing showed surface cracks and, in some, a slight local sloughing off of thin films of binder overloaded with filler. Movement of the surface dressing appeared to be more marked with bitumens than with tar,

(6) In the case of the Pakur (Bengal) stone the chip being very hard and tough and not easily crushed the surface still presented in the main an open appearance and it appeared that for the binder used the chip was excessively large or excessive in quantity

Primed Sections

(7) The appearance of the sections which had been primed was definitely inferior to those which had not been primed and showed general signs of failure. This was attributed not to any defective qualities in the primers but to the fact that where primers had been used the quantity of binder in the surface dressing had been considerably reduced, and the tentative conclusion of the Committee was that, as far as the Test Track showed the use of a primer did not enable the quantity of binder to be reduced to any great extent

General

(8) On the outer track the width swept out by each wheel was considerably less (7½ inches) than on the inner (15 inches). The outer track had not been tested for an equivalent number of revolutions to give the same amount of wear per superficial area as had the inner and its appearance was generally better

2 The Committee decided to continue the tests on both tracks but to replace the iron tyres by rubber tyres on one cart on each track loaded to about 6 000 pounds giving a wheel load of 3 000 pounds or about 1½ tons which is less than that of an ordinary 25 seater bus

3 The Committee decided that after completion of this set of tests, a further similar set of tests should be carried out after the monsoon on surface dressings as before but

(1) it no longer appeared to be necessary to use each different kind of chip with its own stone in the macadam and that the nearest available stone namely Pakur should be used for the whole perimeter, the top or macadam coat being relaid after stripping the existing one, to the full width and *without camber*.

(2) in view of the slight difference between the behaviour of different binders it would suffice to test only two types of chips representative of the hard and tough and the brittle that is to say the Pakur stone and the Jhansi stone

(3) one track would be primed and the other unprimed the quantities of primer and binder being determined as before upon the advice of the suppliers after the completion of the existing tests This would give longer lengths for test than before

Note —Mr Mitchell wishes to reserve two short lengths of track of about 25 feet each partly on curve and partly on straight for certain special tests which he proposes to specify (A plan of the track showing these and allocating the remainder to the different tests will be prepared and circulated in due course)

The tests to be commenced in October and run continually to destruction with one rubber tyred and one iron tyred cart on each set

Note —In view of the lighter tractive effort which is required than was estimated it would be possible and probably desirable to add a third cart and to use a train of two iron tyred and one rubber tyred on each track The loading of the rubber tyred cart is less than actual loading of a normal 25 seater bus or an equivalent lorry and this proportion would be nearer actual road conditions

Addendum

The Track was inspected by Messrs Mitchell and Stein on the afternoon of Monday the 10th June when one of the carts on each track had been fitted with rubber tyres loaded to 3 000 pounds each and had been run for a relatively small number of turns The effect of the rainfall of the previous week had disappeared and this combined with the effect of the rubber tyre had vastly improved the sections and gave the impression that they would last very much longer than appeared to be probable on Saturday It may not indeed be possible to complete this series of tests to destruction before the monsoon and they may therefore have to be kept for completion of the test thereafter The Members of the Committee present in Calcutta will doubtless visit the track from time to time and form their own impressions

ANNEX IV

Proceedings of the meeting of the Technical Sub Committee of the Indian Roads Congress held in the office of the Director of Industrial Research Bureau Alipore, Calcutta on the 30th September 1940 at 12 noon

The Committee first inspected the Test Track Majherat and examined the condition of the tracks which had been tested practically to complete failure

The top coat in the outer track for a width of one foot was removed in section 7 where Pathankot metal had been used

Mexphalte section No material subsidence of the intermediate metal coat was observed In section 15 where a similar examination was made the Delhi stone had been driven into the intermediate coat and no line of cleavage was apparent The whole was stripped to the brick soling which was found to be in perfect condition

The Committee then adjourned to 11-B Judges Court Road and sat from 11 a m to 1 p m and from 2 30 p m to 6-00 p m

The minutes of the discussions are —

1 The Minutes of the previous meeting on the 11th April 1940 (Annex II page 199) and of the informal meeting of certain members on the 8th June 1940 (Annex III page 226) were confirmed

2 The Committee were of the opinion that the foundation of the Test Track is sound and that no further apprehensions need be entertained on this score They desired however that the top coat be stripped in two or three more places and that where the intermediate coat is found to be depressed or damaged the latter should be stripped to the brick soling This would set the matter beyond doubt (This was subsequently done in two more places In section 3 the soling was found to be perfect In section 20 the intermediate coat was practically perfect the maximum depression measured being 3/8 inch)

3 The Committee considered the suggestions made by Mr Dunbar that a tell tale layer of paper or light hessian should be inserted in future tests between the intermediate and top coats It was felt that any layer sufficiently strong to survive sufficiently well to give any indication would be liable to impede the bond between the two coats As a trial two or three strips of tarred hessian should be laid from side to side of the track in different places for subsequent examination

4 The Committee considered and accepted in principle Mr Murrell s suggestion that the results of the tests should be plotted to scale of numbers of non trips giving for any particular stone or binder or primer a series of points the majority of which could be expected to fall within a definable area the centre of which would give a general relative evaluation Dr Chowdhary agreed to draw up the necessary charts for future tests At the same time the Committee agreed that hasty conclusions should be avoided

5 Upon the completion of the present set of tests in a few days it may be possible to find some correlation between the rate of wear of the 7½ inch and 15 inch wide test strips This if possible may throw light on the correlation between future tests on the 15 inch strips and the total tonnage of traffic on a 10-foot road The Committee decided that it would be desirable if possible to exhibit future results in terms of the approximate equivalent tonnage *per 24 hours plus the unit* weight of carts

6 The Committee having read Dr Chowdhary s very informative report* for the period 6 7 40 to 3 9 40 remarked —

(*a*) that in future copies of these periodic reports should be supplied by the Congress office to the members of the Committee as soon as possible after receipt

(*b*) that with reference to the failure of the Delhi stone test lengths (sub paragraph (1) under tentative conclusions) *the Committee wished to add after smaller sized the* words and partly rounded (worn)

(*c*) that the results so far obtained reveal qualitatively and in the climate of Calcutta no difference in the behaviour of different stones with different binders

7 *Future Tests* —These should be continued for one trial more on surface treatment as follows —

(*a*) Both tracks should be swept to identical widths on the long 48 foot wave

(*b*) As before the specifications will be laid for the test strips only with margin the remainder being merely sealed

(*c*) The test strips to be surfaced up by preliminary running of the rubber tyred and ordinary iron tyred carts lightly loaded to 15 inches or 18 inches if possible When sur*facing up is deemed to be satisfactory, the width swept* will be reduced to 13 inches or 10 inches and the tests commenced

(*d*) Half the test strips to be primed and half unprimed on each set of tracks With the exception of the slight difference in length the outer tracks (A and B) are to be an exact replica of the inner (C and D) as a control

(*e*) The running of the tractors should be adjusted so that the total ton trips over each set of tracks shall be identical over any period not exceeding one week (The outer tractor will have to be started up first and continued longer each day)

(*f*) The wearing coat will be all Pakur stone The chips used will be Pakur and Jhansi only

(*g*) On the inside of the end curved sections consolidation of the wearing coat will be against a brick-on edge kerb After consolidation this will be removed and replaced by a pre cast cement concrete kerb 12 inches deep and 6 inches wide cast in convenient say 3 feet lengths well punned and supported behind

*Not reproduced

(h) The wearing coat will be laid without camber The intermediate coat will have to be picked up on the haunches and metal added to bring it up to a flat section Where there are grooves as under the Delhi stone the same will be necessary (Note should be kept of the places where the intermediate coat has been wholly relaid or extensively repaired)

(i) The quantities of materials per 100 square feet to be used are as follows —

1	Primer	23 lbs ± 1 lbs
2	Binders the same both with and without primer	55 lbs ± 2 lbs

N B —The above weights of primer and binder refer to bitumen A correction to be made in the case of tar according to specific gravity at air temperature to get the same volume

3	Chips	5 cu ft ± 0 25 cu ft

(j) As regards the blinding with sand 15 feet on the curve of the 50 feet reserved for Mr Mitchell to be placed at Mr Shannon s disposal for a test of sand blinding to be laid to his own specification which he will record

(k) The use of one iron tyred and one pneumatic tyred cart to be continued in each track The pneumatic tyred cart is to be loaded to 3 000 pounds on each wheel (total 6 000 pounds) and the iron tyred cart to be loaded to 500 pounds per inch width of tyre (total approximately 1 750 pounds) Lighter loadings may be used if necessary for the preliminary surfacing referred to in sub-para (c) above Provided that the surfaces hold out the tests at this load (6 000 pounds and 1 750 pounds) are to be continued up to a total of 10 000 ton trips

(l) Mr Stein will convene periodical meetings of the local members of the Committee to examine and report progress whenever the Superintendent of the Test House wishes for advice

8 The Committee received Mr Murrell s suggested glossary of additional road terms and decided that individual members should submit their comments to the Secretary of the Indian Roads Congress so that a summary can be prepared for the next meeting Mr Shannon undertook to obtain a copy of the Glossary recently issued by the British Standards Institution and to refer to this in his comments.

9 The Committee informally discussed the question of holding the next Indian Roads Congress regarding which the Secretary is shortly addressing the Council The Committee favoured holding the Council meeting only possibly at Ranchi due to congestion in Delhi

ANNEX V.

Minutes of Informal Meeting of certain Members of the Technical Sub-Committee of the Indian Roads Congress and co-opted members, held at Calcutta on the 16th December 1940 at the Test Track.

1 *Size and proportion of chips for set of tests now to be carried out.* Decided for all test lengths two thirds of ⅝" and one third of ½", applied separately

2 *Parallel or control tests on roads.* Decided :

(i) The tests at Delhi to be proceeded with

(ii) The tests at Cawnpore and elsewhere not to be proceeded with

(iii) To get controlled tests under identical road conditions with same standards of consolidation, etc. Chief Engineer, United Provinces, to be asked to carry out the following on the Agra-Delhi road near Agra (or some similar road where both Jhansi and Delhi stones are about equi distant for lead) The work to be under the supervision of the suppliers of the binders Half furlong each of Delhi and Jhansi stones with and without primer—hot or cold—using Tar, Mexphalte and Socony Metalling to be same as chips and road to be newly metalled with at least a 2½-inch loose measurement, graft coat

Quantities :—(a) *Unprimed sections*

Binders — 50 lbs. ± 2 lbs
Chips — 5 to 6 cft. 2/3rds of 5/8" and ⅓rd of ½".

(b) *Primed sections*

Primer — 22 lbs ± 2 lbs
Binder — 40 lbs. ± 2 lbs.

Chips—5 to 6 cubic feet of grading as above but this *quantity can be departed from if the supplier of the* binder considers necessary.

The standard records of experimental work already specified by the Congress and regular traffic counts to be made.

The length will be :—

3 binders × 2 stones × 2 sections (primed and unprimed) =12 lengths of ½ furlong each = 6 furlongs

Consolidation to be to ordinary United Provinces 1st Class specification.

The road to be closed to traffic from the commencement of consolidation until the whole is finished and dried, the consolidation work being

kept watered so as to ensure as far as possible ... content when opened to traffic

The road should be opened to traffic ... (the officer in charge will use his judgment) and ... ing All will be opened to traffic at once

Work to be done so that painting is done ... of temperature

ANNEX VI

Extract from the Minutes of the Seventeenth Meeting of the Council of the Indian Roads Congress held at Delhi on the 28th January 1941

* * * *

29 *Consideration of the Report* of the Technical Sub Committee* After some discussion the Council accepted the Report of the ... Sub Committee subject to the deletion of the words ... occurring on page 197 paragraph 10 (ii) of the Report ...

* * * *

ANNEX VII

Report regarding Brick Bonded Concrete Road constructed at Navsari

The old metalled road was observed to rut very badly and developed pot holes under modern mixed traffic of bullock carts and motors which required thorough repairs every second or third year In order to maintain the surface in a satisfactory condition it was decided to treat a section of this road about 1730 feet in length and 16 feet wide on the road from Tata A V School to Poorna River Bridge with brick bonded concrete surface to obtain a modern surface at economical cost and suitable for modern traffic

2 The work was done in October 1937

3 *Details of brick bonded concrete road work* —The old metal road surface had no proper alignment nor grade nor camber It was also rutted and the surface was wavy At certain places the thickness

*Vide Page 191 to Page 197

of metal was not enough but the subgrade on the whole was found to be unyielding Re sectioning work with gravel and metal, therefore, had to be done to bring the surface to a camber of 1 in 72

The thickness of brick bonded road was 4½ inches Bricks 9' by 4½ by 3 were laid flat after applying thick cement wash to the prepared subgrade, with 1½" wide joints alround each brick This cement wash was discontinued further as expansion joints were decided to be kept at every 30 feet The bricks were thoroughly soaked in water before use About 220 bricks were required for every 100 square feet including wastage at 10 per cent The proportion of concrete used for filling up joints was 1 3 6, and mixture of gravel and stone *keplchi* was used as coarse aggregate The *top 1½' thick concrete* was made of 1 2 4 with coarse aggregate as above

Transverse expansion joints ½ inch thick, which were provided at every 30 feet, were subsequently filled with sand and bitumen No *longitudinal joint was kept as the width of the road so treated was only* 16 feet

Tamping screeding, finishing and curing were done as per standard practices for roads The surface was finally treated with 3 coats of silicate of soda, 1 to 5, after the curing period was over

4 *Cost* —The cost of the re sectioning work, including the cost of materials required, was Rs 2/12/- per 100 square feet The cost of 4½ inches brick bonded road surface was Rs 26/4/- per 100 square feet

5 *Nature of Traffic* —The traffic on this road is of mixed type with bullock carts, as well as motor lorries and buses, etc The intensity of traffic per day of 24 hours is about 600 tons

This brick bonded road surface behaved quite satisfactorily in the beginning under this traffic, but subsequently pot holes and cracks were developed No particular reasons can be attributed to these cracks but probably they may be due to the soft subgrade or due to not allowing one monsoon to pass over the re sectioned subgrade for proper consolidation and settlement under traffic The development of pot-holes may be due to the part use of gravel as coarse aggregate as experience shows that gravel is most unsuitable for wearing surfaces Anyhow, the surface became rather bad after about 2 years from its construction, and, therefore, it had to be treated with 1-inch asphalt carpet, which work was executed in February 1940 The asphalt carpet is observed to wear well under the traffic

APPENDIX II

TOURS AND OTHER FUNCTIONS HELD DURING THE COUNCIL MEETING OF THE INDIAN ROADS CONGRESS DELHI JANUARY 1941

Thursday January 23 1941

After the group photograph with the Hon ble Sir A G Clow C S I C I E I C S and the Hon ble Mr S N Roy C S I C I E, I C S and other guests the delegates assembled at the New Delhi Town Hall at 11 00 a m when Mr A W H Dean M C E D Superintending Engineer Delhi Province briefly introduced the Notes on works to be visited in Delhi Province He was followed by Mr Mahabir Prasad Officiating Chief Engineer United Provinces who introduced the portion of the notes relating to Ghaziabad Bulandshahr road

At 11 30 a m the delegates proceeded in taxis to inspect the following works —

1 INCH PREMIX SOCONY MACADAM ON PARLIAMENT STREET

(i) PORTION H 2 TO O 4

This 1 inch carpet of Socony Asphalt grade 101 was laid in June 1934 at a cost of Rs 9 8 per hundred square feet (*vide* I R C Proceedings Volume I page 33)

In 1937 it was noticed that the stone aggregate of carpet was exposed and was getting worn away by traffic A seal coat with liquid asphalt was therefore provided in 1938 This was done at a cost of Rs 1 1? per hundred square feet using Liquid Asphalt at o pounds and Badarpur sand The road is in good order Traffic consists mostly of rubber tyred vehicles

(ii) CIRCUS H 2

This Circus received the same treatment as the portion referred to above the treatment was also given at the same time Subsequent treatment was found necessary in 1939 when re painting was done using Hot Socony Grade 105 at 25 pounds with stone chips The cost was Rs 2 4/ per hundred square feet

EXPERIMENT OF SMOOTHENING COAT WITH DRAG SCREED

Repairs to road surface by appplication of re painting coats does not improve the surface so far as the evenness is concerned In fact if the surface has become wavy or corrugated the defects are if anything accentuated by re painting If a carpet is laid on such a road the undulations repeat themselves in course of time It has therefore been the practice to re-metal the road when the surface had become very

uneven This process is not only expensive, as nothing less than two coats of painting on the new waterbound surface are satisfactory, but also causes a great deal of inconvenience to the public, as the road has to remain closed to traffic for a long time This applies specially to roads in a town It has, therefore, been attempted to repair uneven road surfaces without recourse to the renewal of its metalling

Experiments for applying smoothening coats have been performed on Irwin Road New Delhi (see plan on page 237) The road surface had become quite uneven having been painted and re painted four times since 1929 The experiment was carried out as below —

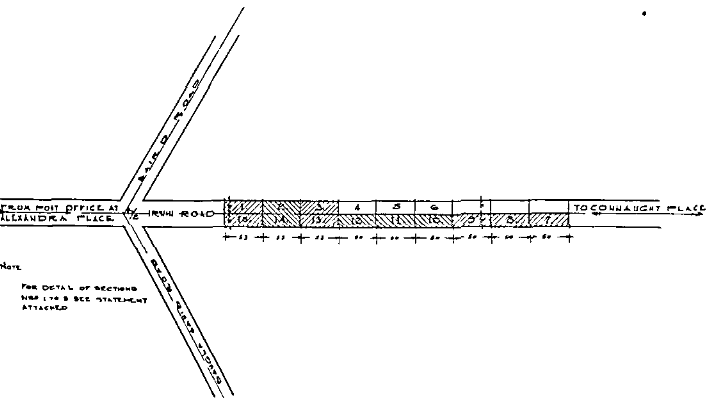
Painted road surface was cleaned as is done for ordinary work of surface dressing A tack coat of Bitumen (Colasmix Indospra or Shelspra) was given using 8 to 10 pounds of material per hundred square feet Stone grit of size ⅛ inch downwards was premixed in hand operated revolving drums using 5 to 7 pounds of Colasmix per cubic foot of grit or 3½ pounds of Shelspra or Indospra per cubic foot of grit Shelspra was heated to 250 degrees Fahrenheit and Indospra to 225 degrees Fahrenheit before premixing The pre coated grit was laid on road surface by the help of a Drag Screed, in which the blade was adjusted so that it just cleared the high spots The pre coated grit was loaded in the space in front of the blade and the screed was pulled forward by about 8 men The grit was thus spread to form an even surface as shown below —



The surface so prepared was then rolled with a light roller In the case of Colasmix, the rolling was done 3 hours after laying in order to let the emulsion break In case of Shelspra and Indospra rolling was done soon after laying The road was kept closed for 48 hours after rolling, so that the surface could become hard

It was observed that the first smoothening coat formed slight depressions after being opened to traffic for a few days The depressions appeared where the thickness of grit was more as that thickness compacted further under traffic A second smoothening coat was therefore, applied in certain sections to see the effect The work was done exactly in the same way as in the case of the first coat except that the tack coat was lighter, consisting of 4 pounds of Colasmix per hundred square feet, diluted with an equal quantity of water

The treatment as described above was done in 12 sections, each 15 feet by 50 feet The details for each section are given in the statements facing page 238


INDEX PLAN SHOWING SMOOTHENING COAT TREATMENTS CARRIED OUT ON IRWIN ROAD, NEW DELHI.
FROM POST OFFICE AT ALEXANDRA PLACE
IRWIN ROAD
TO CONNAUGHT PLACE
BAIRD ROAD
NOTE
FOR DETAIL OF SECTIONS NOS 1 TO 8 SEE STATEMENT ATTACHED

2½ INCH SOCONY CARPET CONNAUGHT PLACE

PORTION FROM IRWIN ROAD TO CHELMSFORD ROAD

This 2½ inch carpet was laid in 1936 using Socony Asphalt Grade 101 The work was done in two coats The following materials were used per hundred square feet in the first coat —

2 to ½" stone chips	15 cubic feet
Socony	37 45 pounds
Socosol	6 per cent of asphalt

In the second coat the following materials were used per hundred square feet —

Stone Chips (¾"—½")	10 cubic feet
Binder (a) Socony Grade 101	30—35 pounds
(b) Socosol	6 per cent of asphalt
Blinding Stone Dust	2 cubic feet

The cost was Rs 16/ per hundred square feet

Light re painting was found necessary in 1940 and this was done with Socony Asphalt Grade 105 at 20 pounds per hundred square feet and stone chips The cost was Rs 2/6/ per hundred square feet

The condition of the road is good Traffic is heavy and consists of both motor vehicles and bullock carts

2½ INCH SHELCRETE QUTAB ROAD

FROM CONNAUGHT PLACE TO ITS JUNCTION WITH PAHARGUNJ (ABOUT ½ MILE)

This was laid in October 1934 at a cost of Rs 21/ per hundred square feet (*vide* I R C Proceedings Volume I page 24) The surface was given a seal coat with F 70 in June 1937 (*vide* I R C Proceedings Volume III page 48) Traffic is heavy specially village carts The following experimental seal coats have since been applied on three sections of this length —

(1) *From Connaught Place Junction to office of the Divisional Superintendent North Western Railway*

Seal coat with F 70 at 20 pounds blinded with Badarpur sand at 2 cubic feet This was applied in May 1940 at a cost of Rs 2/6/ per hundred square feet The central portion of the road is exposed and cracks are showing

(2) *From office of the Divisional Superintendent North Western Railway to Exit of Indian Railway Conference Association*

in June 1940 with Digboi Indospra (400—500) at 20 pounds with Badarpur sand at 2 cubic feet at a cost of Rs 2/14/ per The surface is in good condition

2½-INCH SOCONY CARPET, CONNAUGHT PLACE

PORTION FROM IRWIN ROAD TO CHELMSFORD ROAD

This 2½-inch carpet was laid in 1936 using Socony Asphalt, Grade 101. The work was done in two coats The following materials were used per hundred square feet in the first coat —

2" to ½" stone chips..... 15 cubic feet
Socony.... ... .37-45 pounds
Socosol.. ....6 per cent of asphalt

In the second coat the following materials were used per hundred square feet —

Stone Chips (¾"–¼") . . ..10 cubic feet
Binder (a) Socony, Grade 101.. .....30–35 pounds
(b) Socosol . ... .6 per cent of asphalt
Blinding, Stone Dust ....2 cubic feet
The cost was Rs 16/- per hundred square feet

Light re-painting was found necessary in 1940, and this was done with Socony Asphalt, Grade 105, at 20 pounds per hundred square feet, and stone chips The cost was Rs 2/6/ per hundred square feet

The condition of the road is good Traffic is heavy, and consists of both motor vehicles and bullock carts

2½ INCH SHELCRETE, QUTAB ROAD

FROM CONNAUGHT PLACE TO ITS JUNCTION WITH PAHARGUNJ (ABOUT ½ MILE).

This was laid in October 1934 at a cost of Rs 21/- per hundred square feet (*vide* I R C Proceedings, Volume I, page 24) The surface was given a seal coat with F 70 in June 1937 (*vide* I R C Proceedings, Volume III, page 48) Traffic is heavy, specially village carts The following experimental seal coats have since been applied on three sections of this length —

(1) *From Connaught Place Junction to office of the Divisional Superintendent, North Western Railway.*

Seal coat with F 70 at 20 pounds, blinded with Badarpur sand at 2 cubic feet This was applied in May 1940 at a cost of Rs 2/6/- per hundred square feet The central portion of the road is exposed and cracks are showing

(2) *From office of the Divisional Superintendent, North Western Railway to Exit of Indian Railway Conference Association*

Sealed in June 1940 with Digboi Indospra (400—500) at 20 pounds and blinded with Badarpur sand at 2 cubic feet at a cost of Rs 2/14/- per hundred square feet The surface is in good condition.

(3) *From Exit of Indian Railway Conference Association to the centre of the same*

Sealed in June 1940 with Digboi Inlojan (400–500) at 20 pounds and blinded with 2 cubic feet of ⅜ inch stone grit at a cost of Rs 2 14 per hundred square feet The surface is in good condition

The remaining length from the centre of Indian Railway Conference Association to its junction with Pahargunj has not been treated The surface is showing cracks and patch repairs have become necessary

SOCONY ON MUTINY MEMORIAL ROAD

This treatment lies in the section from (1) Point to the Lady Reading Health School The original surface was a re paint with Hot Socony done in 1935 36 at the rate of 25 pounds and 3 cubic feet stone grit at a cost of Rs 3 3 per hundred square feet

The portion from (1) Point to Idgah was widened from 15 feet to 24 feet in 1937 38 using 6 inches stone soling and a 4 inches wearing coat of stone metal The widened portion was given a first coat of Socony Liquid Asphalt at 25 pounds and blinded with 2 cubic feet of Badarpur sand per hundred square feet This was followed by a second coat of Hot Socony at 30 pounds and 3½ cubic feet stone grit per hundred square feet The cost of this two coat treatment was Rs 5 1-/ per hundred square feet

The central portion or original road width was treated at the same time with a single coat of painting of Hot Socony at 25 pounds and 3½ cubic feet stone grit at a cost of Rs 2 14 per hundred square feet The *surface is rough and wavy and it is proposed to recondition* it in 1941 42 using 4½ inches new metal and double coat painting The length from the new Shidipura Circus which lies in the Model Basti is proposed for widening and improvement next year The road width will be increased to 32 feet

The *portion from the* Lady Peading Health School to the junction with the Grand Trunk Road to Karnal is cement concrete (1 2 4) 7 5 7 section laid in 1938 Only minor repairs to pot holes have been found necessary

1½ INCH BITUMEN ARMOUR COAT ON GRAND TRUNK ROAD TO KARNAL

Furlong 2 4 to Furlong 2/7

The original treatment of 1½ inches Armour Coat with Tar Bitumen Mixture (Mixture A Tar 75% and Bitumen 25% and Mixture B Tar 70% and Bitumen 30%) was laid in October 1934 at a cost of Rs 15 8/ per hundred square feet (*vide* pages 30 31 of I R C Proceedings Volume I) The road is subject to all kinds of traffic especially village carts and tongas intensity being 237 tons per yard width The surface became very uneven (*vide* page 40 I R C Proceedings Volume and was

covered with 2½ inch Shelcrete in October 1937 (*vide* pages 48 49, I R C Proceedings Volume III) Since this was done, the maintenance has been negligible The original treatment was a failure

Furlong 2/8 and Furlong 3/1

The original treatment of 1½ inches Armour Coat with Colas Emulsion was laid in September 1934 at a cost of Rs 12/- per hundred square feet (*vide* page 30, I R C Proceedings Volume I and page 41 I R C Proceedings Volume III) Furlong 2/8 was covered with 2½-inch Shelcrete in October 1937 The original treatment was a comparative failure It gave less service than its cost warrants Furlong 3/1 has been re treated with 1½ inches Bitumuls Armour Coat in June 1940 at a cost of Rs 12/-/- per hundred square feet

Furlong 3/2 and Furlong 3/3

The original treatment of 1½ inches Armour Coat with Bitumuls was laid in October 1934 at a cost of Rs 14/ /- per hundred square feet (*vide* pages 28 and 29 I R C Proceedings Volume I and page 42 I R C Proceedings Volume III) It commenced to show signs of disintegration and extensive patch repairs have been carried out Furlong 3/2 was re-treated in June 1940 with the same material at a cost of Rs 12/- per hundred square feet This is certainly better than any other 'Armour Coat type of service

Furlong 3/4.

1½ inches Tar Bitumuls Premix was laid in November 1934 (*vide* page 29 I R C Proceedings Volume I) Surface is wavy and extensive patch repairs are necessary

Furlong 3/5 to Furlong 3/8

This is 2½ inches Shelcrete done in October 1937 (*vide* pages 24 25 I R C Proceedings, Volume I, and page 49 I R C Proceedings Volume III)

TWO COAT PAINTING AND SOCONY

Widened portion Grand Trunk Road to Karnal

This extends from mile 7 to the border at mile 16 The road was widened throughout in 1937-38 from 12 feet to 16 feet with 6 inches stone soling and 4½ inches wearing coat of stone metal The widened portion was treated with Liquid Asphalt late in 1937 38 using 25 pounds of binder and 2 cubic feet of Badarpur sand at a cost of Rs 3/8 per hundred square feet This was followed early in 1938 39 (*i e* after 5 months), by a second coat of Hot Socony Asphalt over the full width of 16 feet using 25 pounds of binder and 3½ cubic feet of stone grit at a cost of Rs 2/14/ per hundred square feet The surface is standing up satisfactorily

TAR CARPET OPPOSITE MAIDENS HOTEL

This 1 inch Tar Carpet Sealed with Tar was laid in March 1934 (*vide* pages 26-27, I R C Proceedings Volume I) The surface was found to require treatment and the length from Wall Street junction to Furlong 3 8 was re-painted with Shalimar Tar No 2 at the rate of 25 pounds, and 3 cubic feet stone grit in September 1940, at a cost of Rs 2/6 per hundred square feet

At 13-30 p. m the delegates returned to their lodgings.

The delegates re-assembled at Windsor Place at 14-30 p m. and proceeded to Muttra road, to see the Drag Spreader and the Drag Broom at work.

DRAG SPREADER AND DRAG BROOM

(i) *Specification for smoothening and laying of new wearing surface of ¾ inch pre coated chippings carpet with Colasmix over a painted and deformed road surface by means of the "Drag Spreader"*

1 Smoothening calls for one or more application of a tack coat of Colasmix at the rate of 10 pounds per hundred square feet The Colasmix should be applied over the previously cleaned painted surface

⅜ inch size stone chippings pre coated with Colasmix at 6 pounds per cubic foot should be spread evenly by means of the Drag Spreader over the tack coat The quantity of chippings to be used depends on the condition of the existing surface After laying and spreading, rolling should be done in the evening, not before.

2. If the road is in sufficiently bad condition to require a second smoothening course then the second operation would be to give a tack coat at 4 pounds per hundred square feet and, in order to do this, an equal quantity of water may be added to facilitate spreading after which ⅜ inch pre coated stone chippings as above should be spread and consolidated

After both or either of these operations, the road can be opened to traffic after 24 hours and it is of advantage to allow the traffic to use the smoothening coat for at least a week, as by doing so it can be seen, before the final wearing coat is given whether the defects in the original surface have been completely remedied

Wearing Coat :—A light tack coat of Colasmix is necessary and this should be given as for operation 2 above

¾ inch to ½ inch size stone chippings pre coated with Colasmix at 6 pounds per cubic foot should be spread by means of the Drag Spreader and this course should be rolled in the evening with an 8 to 10-ton roller. The road can be opened to traffic after 48 to 72 hours

It should be noted that this specification can also be carried out with 400-500 Shelspra B S

(ii) *Specifications for Mix in Place Work with Drag Broom, (over a previously bitumenized surface)*

General :—This specification is recommended for use in lieu of ordinary re-painting on bitumenous surfaces which have become rough or uneven and require a certain degree of correction It can also be adopted for unpainted surfaces by increasing quantities and using large aggregates

Materials —

Aggregates —The mineral aggregate shall be Delhi stone chips and the various sizes required shall be stacked separately after necessary screening to eliminate all dust and foreign matter before starting the work For the preliminary mixing the aggregate shall pass a ¾ inch mesh and retained on a ½ inch screen and for filling up the voids the aggregate passing ½ inch screen and retained on ⅛ inch screen shall be used *Coarse sand or stone screenings shall be used for final filling up of the voids*

Binder —The asphaltic material used as a binder shall be SOCONY SOCOFIX *a cut back asphalt with about 80 per cent bitumen dissolved in* light distillates as marketted by Messrs Standard Vacuum Oil Company

Procedure —The surface to be treated shall be true to grade and camber and any depressions exceeding ¹ inch in depth shall be repaired with a mixture of Socofix and chips at least 2—3 weeks in advance

The surface shall be cleaned as for painting and Socofix applied through distributing tins at 15—17 pounds per hundred square feet and the binder brushed out uniformly and immediately covered with ¾ inch chips at 5 cubic feet per hundred square feet

The surface shall be rolled once or twice and then given a further application of Socofix at 13—16 pounds per hundred square feet No attempt shall be made to brush out

Drag brooming to and fro shall be continued until the chips present a uniform pepper and salt appearance Any light spots remaining on the edges shall if necessary be mixed by coolies with hand bass brooms

The surface shall then be rolled and drag broomed simultaneously by using the roller to tow the drag broom and rolls kept damped to prevent picking up Wherever the drag is found not bearing on the surface it shall be touched up with a very light application of fresh chips and Socofix

The surface shall be rolled without the drag broom and on bare patches ⅜ inch chips previously premixed with Socofix shall be sprinkled

The whole surface shall then be covered with ⅜ inch chips at 2 cubic feet for hundred square feet and rolling and dragging continued until the surface closes up

The surface shall be finished off with a final application of coarse sand or stone screenings at 1 cubic foot per hundred square feet rolled and opened to traffic the following day

The delegates returned to their lodgings at 16-00 p m

2½ INCH SHELCRETE

MILE 2 PARTS OF FURLONGS 6 AND 7 AND MILE 4 FURLONGS 4 AND 5

2½ inch Shelcrete was laid during November 1934 and 1935 at a cost of Rs 21/ per hundred square feet (*vide* pages 24 25 I R C Proceedings Volume I and page 50 Volume III) Minor patch repairs have had to be done During July 1937 a seal coat with F 70 was given to the surface (*vide* page 50 I R C Proceedings Volume I) Another seal coat with the same material has been given during June 1940 The surface is standing up well The traffic is heavy specially of four wheeled carts the intensity being 287 tons per yard width

SOCONY PAINTING

MILE 2 PART OF FURLONG 6

In March 1932 the road surface was given a paint coat with Socony (*vide* pages 21 22 I R C Proceedings Volume I and page 32 I R C Proceedings Volume III) The surface was re painted with Spramex during July 1937 and was re painted during July 1940 with the same material using 25 pounds of binder and 3 cubic feet of stone grit at a cost of Rs 2/14 per hundred square feet The original treatment was quite satisfactory

2½ INCH HOT SOCONY PREMIX

MILE 2 FURLONGS 2 AND 3

This treatment was laid during November 1934 at a cost of Rs 17/8/ per hundred square feet (*vide* page 46 I R C Proceedings Volume I and page 50 I R C Proceedings Volume III) Patch repairs have been carried out and the surface is slightly wavy A re paint coat will be necessary in the near future

2½ INCH GROUTING WITH MEXPHALTE 30—40

MILE 2 FURLONG 1 AND MILE 3 FURLONGS 2 TO 8

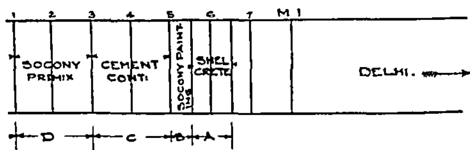
This is the original treatment that was done in March 1933 (*vide* page 22 I R C Proceedings Volume I) Patch repairs have been carried out to this surface A re-paint coat will be necessary in the near future The treatment has stood well Traffic intensity is 287 tons per yard width

2½ INCH GROUTING WITH HOT SOCONY

MILE 3 FURLONG 1 AND MILE 4 FURLONGS 6 7 AND 8

This is also the original treatment that was done in March 1933 (*vide* pages 22 23 I R C Proceedings Volume I) Patch repairs have been carried out The treatment has stood well Intensity of traffic is 287 tons per yard width

RIMENTS.


1
2
3
4
5
6
7
M 1
SOCONY PREMIX
CEMENT CONTI
SOCONY PAINT
SHELL CRETE
DELHI.
D
C
B
A

2½ INCH TRINIMAC

MILE 4 FURLONG 3

This is the original surface done in November 1934 (vide page 47 I R C Proceedings Volume I and page 45 Volume III) Surface has had to be patched up at several places but has stood well Re paint coat will be necessary in the near future Intensity of traffic is 287 tons per yard width

EXPERIMENTAL BRICK TRACKWAYS ON DELHI MEERUT ROAD

Several miles of new roads to take occasional heavy motor traffic have to be constructed expeditiously as an emergent measure in places where road materials are not available for construction and water is scarce Bricks could however be manufactured at some distance from road and carted and it has been proposed to adopt brick trackways as an emergent measure Before adopting any particular specification for the brick track ways which have not so far been tried on any large scale it was considered desirable to have experimental stretches of these laid to different specifications on a road subjected only to motor traffic and see how these behave under traffic Delhi Meerut road between Delhi and Shahdara was specially selected as on this stretch of road there is segregation of traffic the cement concrete road being reserved for cart and tonga traffic and the asphalt road for motor traffic only Further the place is very near Delhi where the specifications could be rigidly enforced under proper departmental supervision Two sections were chosen on the motor road one of 300 feet near Badshahi bridge and another of 600 feet near the canal During construction all motor traffic was diverted by means of ramps on to the concrete road now reserved for carts and tongas

To make the experiments conform to the actual construction on earth roads the metalling and soling on the Delhi Meerut road were removed and the formation level brought up by earth filling dressed watered and consolidated in layers by sheeps foot rammers and rollers at optimum moisture content Trenches were then excavated to the required width and the bottom consolidated again with sheeps foot rammers The track ways were then laid All the trackways have been completed by 3rd January 1941 Traffic will be allowed over these after concrete is cured

The trackways consist of two tracks each 2 9 wide and spaced 5 6 centre to centre The designs adopted are shown in the plans opposite and the specifications are detailed below —

Experiment No I

Brick on edge laid with ¼ joints the joints to be sanded to within ½ of the top and then grouted with as much as they will take of

1	(a)	Tar No 2	50 feet length herring bone bond	Sketch No I
	(b)	Bitumen	50 feet length herring bone bond	
2	(a)	Tar No 2	25 feet	Header and Stretcher bond
	(b)	Bitumen	25 feet	

Experiment No II

Brick on edge laid with bricks half dipped in

1	(a)	Tar No 2	50 feet length	Herring bone bond
	(b)	Bitumen	50 feet length	
2	(a)	Tar No 2	25 feet	Header and Stretcher bond
	(b)	Bitumen	25 feet	

Experiment No III

Cement concrete trackways with brick ballast (1 gauge) Badarpur sand and cement in the proportion of 4 2 1 laid in 25 feet lengths joints staggered each joint ¼ with pre cast bituminous joint filler

1	(a) 6 thick with cantilever end reinforcement	75 feet
	(b) 6 thick without any reinforcement	75 feet
2	(a) 4" thick with cantilever end reinforcement	75 feet
	(b) 4 thick without any reinforcement	75 feet

Cantilever end reinforcement to consist of 4 nos 3/8 diameter mild steel rounds 2 6" long

Experiment No IV

Brick bonded brick ballast cement concrete (Sketch No 2)

With flat bricks bonded with brick ballast cement concrete 1 2 4 Total thickness 6

(a) 50 feet length with cantilever end reinforcement
(b) 50 feet length without any reinforcement

Experiment No V

Brick bonded brick ballast cement concrete (Sketch No 3)

With bricks on edge bonded with brick ballast cement concrete 1 2 4 thickness 6½"

(a) 50 feet length with cantilever end reinforcement

(b) 50 feet length without any reinforcement

Experiment No VI

Brick bonded brick ballast cement concrete (Sketch No 4)

With specially burnt semi eliptical bricks with 1 2 4 brick ballast cement concrete thickness 6"

(a) 50 feet length with cantilever end reinforcement

(b) 50 feet length without any reinforcement

Experiment No VII

Dry Brick Trackways without any grouting

(a) 50 feet length Herring bone bond

(b) 50 feet length Header and Stretcher bond

In experiments Nos III to VI half of each experimental length has been done with selected blue '*Jhama* brick ballast and the remaining half with assorted brick ballast *i e*, brick ballast from which only honey combed or under burnt material has been eliminated

The work is estimated to cost Rs 3,200 Accurate records of all quantities have been kept for costing

GRAND TRUNK ROAD

The section of the Grand Trunk Road between Bulandshahr and Ghaziabad was upto the year 1933 in a very bad condition inspite of continued renewals and maintenance The life of the waterbound *kankar* surface was on an average only 2 years and the expenditure on maintenance high

The proposal, first sanctioned, was for reconstruction with a 4½ inch coat of Delhi stone metal and surface dressing with bitumen The actual reconstruction was to be completed in two years and the contractor was made responsible for maintenance for ten years after the completion The length of the section was 30 miles and the contract was given on the basis of competitive tenders at a cost of Rs 3 52 710 and for the maintenance for a period of ten years at a cost of Rs 2 93 250 The total cost of reconstruction and maintenance for ten years would thus have been Rs 6,45 960/ for 30 miles of road *i e* Rs 2,153/- per mile per year

Five miles were reconstructed according to these proposals but as the maintenance cost of the painted surface was expected to be higher than that for a concrete pavement, the contractor offered to reconstruct the road with cement concrete for the same cost payable in ten years inclusive of maintenance. This was made possible with the co operation of the Cement Marketing Company of India Limited who agreed to accept deferred payment for the cement supplied

The result up to date has fully justified the change and it is expected that even after ten years we would be left with a satisfactory road and Government will have a saving on maintenance.

DETAILS OF COST

As the work was done by contract on a lump sum basis exact details of materials etc , are not available The cost was Rs 3/- per square yard

The slab is 12 feet wide throughout and 5½"—3½"—5½" thick laid on an insulation layer of fine sand and cinders as was available The pavement was laid on the alternate bay system without any expansion joints The mix was 1 2 4 The concrete was machine mixed and laid with the help of handworked templates and the surface was hardened with a solution of sodium silicate The work was complet ng

1935 37 Some interesting details were printed in the Indian Concrete Journal of February 1937, pages 43 48 and Proceedings of I R C Volume III, pages 237 and 238

TRAFFIC

The intensity of traffic on the section varies greatly and is the greatest as we approach Ghaziabad In mile 851 which is practically in the middle of the section *the intensity of the traffic is as follows* —

	Motor		Non Motor	
	1934	1939	1934	1939
	Tons	*Tons*	*Tons*	*Tons*
Mile 851	237	428	720	481
Mile 874	594	1268	329	385

It will be seen from the statistics given above that since the road was constructed the traffic of motor vehicles has gone up and that of the non motor traffic, *i e* bullock carts has a tendency to go down

FURTHER REMARKS

While the surface of the pavement has been satisfactory some cracks which are considered up to the present to be due to expansion and contraction have occurred in this section Such cracks are not general on the other cement concrete roads which have been constructed in the United Provinces and it has not been possible yet to fully determine the reasons of the cracks The slabs at a joint which is affected press against each other and gradually rise up in an angle The rise has been noticed to be as much as 6 inches and in one case 18 inches As traffic passes over this raised portion the slabs get cracked transversely and before long the raised portions break into pieces Two photographs showing the risen slabs and the cracks are appended The rise in the ends of the slab in the case of mile 848 was 18 inches and the ends of two bays stood up for more than 60 hours and then fell to pieces Several theories have been put forward for this phenomena but it has not been possible to deter mine the causes correctly For the present it is considered that it is due to the expansion of the concrete slabs which are free to move due to the insulation layer which was given between the slabs and the sub-grade There is no doubt that the cracks are due to the expansion but the curious *thing is that it is only in a particular section that it happens so frequently* During the summer of 1940 there were some half a dozen such cracks and this has happened every year since the construction of the road Observations have shown that the insulation layers in places where these cracks have occurred have been rather thick and in some places it was found as much as 1 inch It may be that the thickness of the insulation layer has got something to do with the cracks

To avoid such expansion cracks in future works the insulation layer has been omitted from the specifications for thin concrete slabs It is considered that the bonding of the thin slabs with the sub grade will prevent unusually high expansion or contraction The results up-to-date have been satisfactory but the slabs laid on the new specifications have not been in existence for a sufficiently long period to establish the ad vantage of bonding over the insulation system

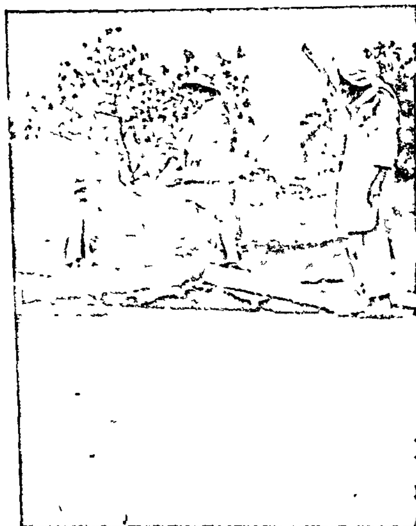


Figure 1 Showing the risen slabs in mile 851



Figure 2 Showing the cracked slabs in mile 851

This year the bursts have occurred amongst others in the following miles —

Date	*Mile*	*Furlong*	*Bay No*	*Temperature*	*Time of occurrence*
25 4 1940	855	7	27	106° F	4 P M
29 4 1940	854	1	154	107° F	4 P M
30 4 1940	848	4	89 and 90	108° F	3 30 P M

Rai Sahib Hari Chand, District Engineer, Concrete Association of India New Delhi circulated to the members of the Council the following note as a possible explanation of the bursts for their consideration at the time of inspection of Mile 851 —

"It has been mentioned on page 248 —

There is no doubt that the cracks are due to expansion but the curious thing is that it is only in a *particular* section

For research into the causes it might be mentioned that the conditions of road subgrade method of construction the cement water ratio and quality of materials was uniform in the whole length of the road, but with *one exception* The cement used in the length of the concrete road from mile 872 to 853 was stored for some time in the godown before use but in the section beyond mile 853 fresh cement, as it daily arrived from the factory, was consumed This was probably done to save double transport charges and also perhaps due to shortage of stored cement

Now, it is a well known fact that

Fresh cement contains a small amount of free or loosely combined lime, which does not slake freely like ordinary limes and causes *expansion* endangering the structure A moderate amount of *seasoning* in weather tight sheds however is often *helpful to secure good results* *vide page 491*, *REINFORCED CONCRETE CONSTRUCTION* Volume II by HOOL

The writer of this note is therefore, of the opinion that the cause of this extra-ordinary expansion is the use of *fresh* cement without allowing it to season by a moderate storage, otherwise there appears no other explanation for this extra ordinary phenomenon

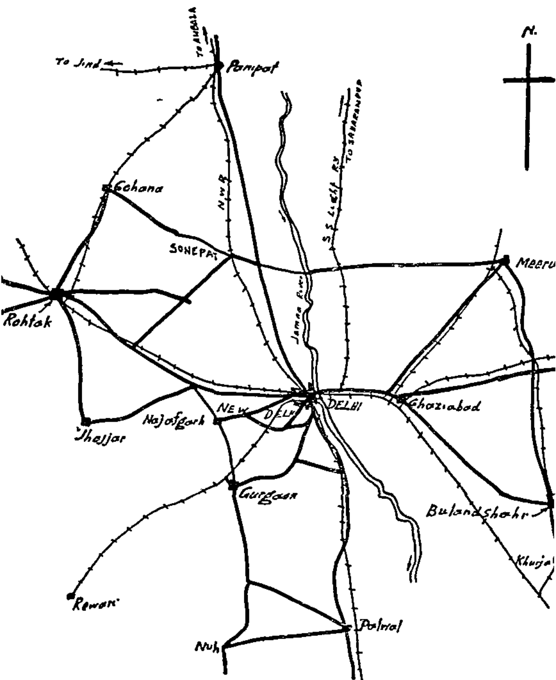
It might be mentioned that otherwise the quality of the concrete is very good, its wearing quality is perfect and the proportion of aggregates as determined by the chemical analysis of a sample, is also exact "

The delegates were entertained to tea at Bulandshahr by Rai Sahib Lala Munna Lal Govilla Engineer and Contractor, Benares City, and thereafter returned to Delhi reaching back their lodging at about 19-00 p m

INDEX MAP SHOWING

DELHI ROHTAK, GOHANA SONEPAT, GHAZIABAD & BULANDSHAHR

SCALE 1" = 16 MILES



Monday 27th January 1941

The delegates assembled at the Town Hall at 10 00 when Mr S R Mehra gave an interesting talk on soil stabilization A summary of this talk is reproduced in Appendix III page 274

At 11 00 the delegates proceeded to the Asmanpur road near the Jumna bridge to see a field work demonstration of soil stabilization

In order to illustrate the various stages in construction of a stabilized soil road a length of one furlong on this unmetalled road had been selected

This road is subject to normally heavy traffic consisting mainly of bullock carts

The length selected for demonstration was rather sandy and subject to quick disintegration in the dry weather under traffic

The laboratory analysis of the sandy soil is as follows —

Retained on No 40 sieve A S T M*	0 per cent
Retained on No 200 sieve A S T M	74 9 per cent
Passing through No 200 sieve A S T M	25 1 per cent
Liquid Limit	25 7
Plastic Limit	19 5
Plasticity Index	6 2

The analysis showed that the soil had a large excess of fine sand and required an admixture of coarse sand and clay for the wearing course Both these materials were available near the selected site and were consequently used Clay was obtained from a deposit nearby and sand was collected from the bed of the Jumna

The laboratory analysis of the admixture is as follows —

Clay

Retained on No 40 sieve A S T M	0 per cent
Retained on No 200 sieve A S T M	17 2 per cent
Passing through No 200 sieve A S T M	82 8 per cent
Liquid Limit	48 9
Plastic Limit	21 6
Plasticity Index	27 3

Coarse Sand

Retained on No 40 sieve A S T M	81 0 per cent
Retained on No 200 sieve A S T M	12 4 per cent
Passing through No 200 sieve A S T M	6 6 per cent.

The mixture selected for use in the wearing course was as follows —

Road soil	Three parts
Jumna soil	One part
Clay	Two parts

For the foundation course the existing soil was considered to be suitable and was loosened to a depth of five inches and compacted by

*American Society of Testing Materials

means of sheeps foot roller, after adding optimum moisture to the soil

Cost —

The details of cost of the demonstration are not typical of this kind of work, as the work had to be done in abnormal circumstances and in a great rush These have therefore been left out

Procedure —

The details of procedure were the same as described for similar details in experiment I in Mr Mehra's paper entitled, 'The use of soil stabilization in unmetalled and metalled roads in India-II,' *vide* pages 141-145 of part 1 of this volume

The demonstration was divided into the following stages —

(a) Collection of clay

(b) Drying of clay and breaking it by means of wooden *thapis*

(c) Dry mixing of sand, clay and soil

(d) Addition of optimum moisture

(e) Preparation of bed

(f) Compaction of foundation course at optimum moisture

(g) Spreading of wearing course material ready mixed at optimum moisture

(h) Rolling the wearing course by power Roller

(i) Finishing the surface

(j) Curing the surface

The members of the council were taken round the work stage by stage by Mr Mehra who explained the practical considerations involved and the difficulties met with in this experiment at each stage

The delegates then proceeded in taxis to inspect the Trackways on the Badli Railway Station Feeder Road The details of this work are given on page 48—50 of volume I (1934) of the Proceedings, and on pages 56 and 57 of part 1 of this volume

The delegates then proceeded to the Sonepat Rest House and were entertained there to a picnic lunch by the President.

After the lunch, they proceeded *via* Rohtak Road and Western Jumna Canal Roads to Gohana Trackways on the Sonepat Gohana *Katchha* Road

Particulars of these trackways are given from page 59 of Sir Kenneth Mitchell's paper appearing in part 1 of this volume.

The delegates walked along the trackways for about a couple of miles and the subject was well discussed at site

The delegates then proceeded to Rohtak *via* Gohana where they were entertained to tea by Sardar Bahadur Captain Dalpat Singh, O B I, I O M, M L A (Central), Member of the Standing Committee for Roads and Chairman, District Board, Rohtak

After the tea, the delegates returned to Delhi arriving at their lodgings at about 19 30 hours

Tuesday, 28th January, 1941

The delegates assembled at Windsor Place at 9-30 hours and proceeded in taxis via Panchkuin Road and Mutiny Memorial Road to the New Rohtak Road to visit the test stretches laid there

Experimental lengths, each a 100 feet long and 24 feet wide, had been laid with binders and primers supplied by each of the following three manufacturers —

(1) Messrs Burmah Shell Oil Storage and Distributing Co

(2) Messrs Standard Vacuum Oil Co, of New York

(3) Messrs Shalimar Tar Products (1935) India Limited.

Two lengths one with a primer and the other without had been laid with the materials of each of the above firms who were also given the discretion to use such quantities of binder and chips as they considered would give the best results The experimental stretches had been laid in a continuous length on the New Rohtak Road with the same kind and size of stone chips and same standard of workmanship and each of these will obviously be subjected to the same intensity of traffic and similar climatic conditions Although therefore the tests were laid in exteremely cold weather, in December 1940 (the temperatures in sun during laying varying from 72° to 76° Fahrenheit only) it is expected that they would yield fairly comparable results

The following were the quantities of materials used in the different stretches and the cost per hundred square feet of treated surface —

(1) Burmah Shell

(*a*) Single coat painting

Mexphalte 80/100 F	53 5 pounds
3 8 stone grit	5 cubic feet
Cost	Rs 6/12/

(*b*) Double coat painting

Shell Primer No 2	17 pounds
Stone grit or sand ..	Nil
Mexphalte 80 100 F	48 1 pounds
3 8 stone grit	4 7 cubic feet
Cost .. .	Rs 7 13/

(2) Shalimar Tar

(*a*) Single coat painting

Shalimar Tar No 1	47 9 pounds
3 8" stone grit	5 cubic feet
Cost	Rs 5 6/

(*b*) Double coat painting

Shalimar Primer No 1	17 3 pounds
Stone grit or sand	Nil
Shalimar Tar No 2	31 7 pounds
3/8" stone grit	4 5 cubic feet
Cost . ..	Rs 5 10 -

(3) Socony

(*a*) Single coat painting

Socony Asphalt 105 J	39 7 pounds
3/8 stone grit	5 cubic feet
Cost	Rs 5/10/

(*b*) Double coat painting

Socofix Primer	21 6 pounds
Stone grit or sand	Nil
Socony Asphalt	31 2 pounds
3/8 stone grit	4 cubic feet
Cost	Rs 7/-

The work was too fresh for any conclusions to be drawn

The delegates then proceeded to the old Rohtak Road and inspected the following road works

CEMENT CONCRETE ON ROHTAK ROAD MILES 2 & 3

Mile 2 Furlongs 1 to 6

This cement concrete 6 4 6 section was laid in 1938 (for specifications see Indian Roads Congress Proceedings page 44 Volume I and page 51 Volume III) The surface was in good condition repairs were necessary near joints

Mile 2 Portion of Furlong 7 and half of Furlong 8

The original treatment was 2½ inch Tar Carpet with seal coat applied at once material being Shal mar Tar No 2 laid in November 1934 (*vide* pages 25 26 *Volume I and page* 46 *Volume* III) It was subjected to heavy traffic especially village carts intensity being 486 tons per yard width The surface became very uneven was removed entirely in November 1937 and replaced by cement concrete (1 2 4) 7" 5" 7" (specifications on pages 37 44 Volume I)

Half of Furlong 8 Mile 2 and half of Furlong 1 Mile 3

Cement concrete 6" 4" 6 was laid in October 1934 at a cost of Rs 34/ per hundred square feet using Bundi Cement Badarpur sand (Budhya Nala) and Jhandewala aggregate (*vide* page 44 Volume I and page 51 Volume III) It is subjected to heavy traffic especially village carts intensity being 486 tons per yard width Some pot holes appeared and have been repaired

Half of Furlong 1 Furlong 2 and half of Furlong 3

Cement concrete 7" 5 7" was laid in June 1934 at a cost of Rs 58/ per hundred square feet using Bundi Cement Badarpur sand and Jhandewala aggregate (*vide* pages 37 44 Volume I and page 51 Volume III) Traffic intensity is 486 tons per yard width consisting of heavy and mostly village carts Some pot holes had appeared and the surface had cracked both longitudinally and across the slab

Half of Furlong 3 and half of Furlong 4

The original treatment given in April 1934 was surface painting with Tar No 2 and Chandigarh ballast at Rs 6 per hundred square feet (*vide* page 29 Volume III) The surface became very bad and in 1937 after the meeting of the Roads Congress the treament was replaced by cement concrete (1 2 4) 7 5" 7 (for specifications see pages 37 44 Volume I) Very little maintenance has been found necessary since then and this has been confined to filling of expansion joints with bitumen

Half of Furlong 4 and half of Furlong 5

The original treatment consisted of 2½ inch water bound tar macadam (Shalimar Tar No 2) laid in April 1934 at a cost of Rs 6 8/ per hundred square feet (*vide* pages 45 46 Volume I and page 44 Volume III) The traffic intensity is 486 tons per yard width By 1937 the surface had become very bad and extensive patch repairs were carried out Eventually in November of that year cement concrete (1 2 4) 7 5" 7 was laid (specifications on pages 37 44 Volume I) It is standing up very well and requires practically no maintenance The original treatment was a complete failure

Half of Furlong 5, Furlong 6 and Furlong 7

The initial treatment given in March 1933 was Mix in Place the binders being (A) F 70 and Mexphalte 30/40 in the proportion of 3 1 in Furlong 5 and Furlong 7 and (B) Colas Emulsion in Furlong 6 (*vide* pages 34 35 Volume I and page 34 Volume III) The cost of treatment was Rs 15/ per hundred square feet Traffic was heavy especially of village carts intensity being 486 tons per yard width The treatment proved a complete failure as the surface developed deep ruts and broke up badly Cement concrete (1 2 4) of 7 5" 7 section was laid in November 1937 (specifications on pages 37 44 Volume I) since which time the maintenance has been confined to joint filling only

2½ INCH SHELCRETE MILES 3 & 4 ROHTAK ROAD

MILE 3 FURLONG 8 MILE 4 FURLONGS 1 & 2

This 2½ inch Shelcrete was laid in April 1934 at a cost of Rs 21 per hundred square feet (*vide* page 49 Volume III and pages 24 25 Volume I) It is subject to the same intensity of traffic as the rest of this mile The surface cracked at a number of places and extensive patch repairs have been done The surface was given a repaint in May 1940 with Spramex at 25 pounds and stone grit at 3 cubic feet at a cost of Rs 2/14/ per hundred square feet

MILE 4 FROM FURLONG 4 TO FURLONG 8

Shelcrete 2½ inch was laid in 1938 (page 40 Volume III) at the rate of Rs 18 8 per hundred square feet This is generally in good condition and no repairs have been necessary ever since it was laid

CEMENT CONCRETE SIDE WIDTHS, ROHTAK ROAD

The side widths are 8 feet wide The mix used is 1 2 4 laid to a 7′ 5″-7′ section (specifications on pages 37-44 Volume I) The work was carried out in 1938 at Rs 38/ per hundred square feet

Except for repairs to a few pot holes and breakages near joints, the surface has not required attention The junction of the Shelcrete and cement concrete has required levelling in spots where depressions had developed

The delegates then returned to the junction of Rohtak and Najafgarh Roads and proceeded to visit the road berms in Mile 3/4 to Mile 3/8 of the Delhi Najafgarh Road, which had been Stabilized with Cement

In the summer of 1940 this work was undertaken with preliminary laboratory study of soil compaction and of the resistance of soil cement mixtures to repeated wetting and drying From these tests it was decided to use 7 per cent of cement by weight of soil This percentage included one per cent for a loss of cement in the various operations of placing and mixing in the execution of work

Tests were also conducted to determine the moisture density relations of the raw soil The optimum moisture content of the soil was found to be 14 per cent of oven dry weight of the soil

The work was started in April and completed in May 1940 Weather conditions in these months were far from satisfactory, the temperature rising to 109 and 110 degrees Fahrenheit and hot winds blowing away considerable amount of cement and moisture Field tests were carried out and an allowance was made for the loss of moisture

Except for initial pulverizing, each section was constructed completely during one day This procedure was necessary because of the rapidity at which the cement hardened after water was applied and the necessity for compacting the mixture at the optimum moisture content before the cement had set The method consisted of mixing in place cement and soil, adding and mixing water, compaction of the damp mix and rolling to finished surface

It was executed entirely by departmental labour. The treatment was carried out on the 6 feet wide berms on both sides of the road from Mile 3/4 to Mile 3/8 The total length treated was 2655 feet on both sides or 5310 feet of 6 feet width, of which 3255 feet was done to a depth of 6 inches and the balance of 2055 feet to a depth of 4 inches

I *Preliminary Laboratory Tests*

The satisfactory percentage of cement as based on compacted oven-dry soil volume was found to be 7 per cent by weight The soil weighed a hundred pounds per cubic foot The soil density test gave the Optimum Moisture Content of 13 77 per cent As the soil was found to contain 3 77 per cent moisture in its natural state this fixed the proportion of water to be added during consolidation at 10 per cent





Figure 2. Spotting cement bags, spreading cement and mixing.

II Construction

The construction is summarized below —

(1) *Pulverizing the soil* The existing road berms were scarified to the required depths (4 inches and 6 inches) by means of the toothed scarifier attached to the Caterpillar Tractor (*vide* Figure 1 opposite page 256) This was accomplished in three or four trips The bottom surface was brought to the required depth and camber by hand using *phaoras* All clods were broken by repeated trips of the sheeps foot roller Foreign bodies such as stone ballast bricks etc were removed and only homogeneous soil passing through a No 10 sieve was retained

2 *Spreading Cement* The pulverized soil was spread evenly on the berms to receive a layer of cement of uniform thickness The cement bags were then spotted in accordance with the area calculated to be covered by one bag of cement at the pre determined ratio of 7 per cent by weight of the cement to soil (*vide* Figure 2 opposite)

3 *Mixing cement with dry soil* Each bag of cement was spread entirely in the area commanded by it and then mixed with the soil by means of *phaoras* until uniformity in colour was obtained (*vide* Figure 2 opposite) Special care was devoted to the mixing to ensure this desideratum before applying water The mix was then laid back on the berm to a uniform level

4 *Application and mixing of water* The quantity of water required for each section was calculated on the pre determined basis of 10 per cent and this was controlled by means of hand watering cans each of 2 5 gallons capacity These cans were fitted with a rose The required quantity of water was applied and the mixing done in two equal batches to ensure uniformity When a uniform mix free from lumps had been obtained the sheeps foot roller was drawn over the surface at high speed by the tractor (*vide* Figure 3 opposite page 258)

5 *Compaction and finishing* The compaction was done with the sheeps foot roller pulled by a 30 horse power grader The roller was ballasted by filling earth in the drum and was worked slowly at first (so that compaction could start from the bottom) and then speeded up so that the dynamic forces would assist in the compaction The roller was worked for 15 minutes over a length of about 300 feet and further rolling was stopped when it was found that except for a small quantity of materials on the surface (which remained loose) the entire thickness of the layer was well compacted The final compaction and shaping to the correct cross section was done with an 8 ton tandem roller (*vide* Figure 4 opposite page 259)

6 *Curing* The finished section was protected from the direct rays of the sun for 24 hours by covering it with date mats which were kept wet This covering prevented evaporation of moisture from the surface and permitted the roadway to harden The work was kept watered for one complete week until the berm was hard set and fit to carry the traffic

Traffic was allowed to pass over the surface after a fortnight of its completion After a few days when the traffic was on fine cracks and loose pockets were observed in the surface These were picked out and

re treated with richer cement soil mixture (cement 10 per cent) separately prepared for the work The results were satisfactory

7 *General observations* The treatment has stood well and is still hard and capable of carrying traffic The section treated to 6 inches depth is standing up better than the 4 inch section

The present indicat on is that the treatment of soils with Portland cement has special merits and is comparatively economical If the surface is treated with a bituminous treatment it will add to its life very considerably

Four photographs depicting the various stages of the work are reproduced

8 *Cost* —A detailed statement of expenditure incurred is given below —

1 FIXED CHARGES ON TOOLS AND PLANTS AND TESTING APPARATUS

(*a*) *Tools and Plant*

	Rs	a	p
Sheeps foot Roller complete with coupling arrangement	1663	0	0
Coupling arrangement on one side	38	8	0
Coupling arrangement on the other side found necessary in use	55	0	0
Templates water cans thermometer sieves lanterns etc	150	0	0
	1906	8	0

(*b*) *Testing Apparatus*

	Rs	a	p
Testing Operations	40	4	0
Penetrometer for soil testing	108	0	0
Supplementary attachment for above	115	0	0
Soil Testing Apparatus	50	0	0
	313	4	0
Total fixed charges = Rs	*2220*	0	0

2 RECURRING CHARGES

1 Cost of Treatment to a depth of 4 inches

Length = *2055 feet* Width = *6 feet*

Area = *12 330 square feet*

(*a*) *Materials*

	Rs	a	p
Cement 260 bags = 13 Tons @ Rs. 38 (Average rate inclusive of carting to site)	494	0	0

(*b*) *Departmental Labour*

	Rs	a	p
Mates 2 Nos × 15 days = 30 @ /11/ per day	20	10	0
Beldars 345 Nos @ /7/6 each	161	12	0
Mason for finishing 1 × 13 @ 1 8 per diem	19	8	0
Mason s Beldar 1 × 13 @ -/7/6 per diem	6	2	0
Bhisties for curing and applying water 4 × 15 days = 60 @ - 7/6 per day	28	2	0
Total	236	2	0

(c) *Recurring expenses of Caterpillar*

Hire charges 12 days @ 2/8/- per day.	..	30 0 0
Driver's wages 12 days @ 3/-/- per day	.	36 0 0
Assistant's wages 12 days @ -/10/- per day.	..	7 8 0
Chowkidar's wages 12 days @ -/7/6 per day.	..	5 10 0
Materials e g Diesel oil, Mobil Oil, Petrol, Cotton Waste etc.	..	60 0 0
Total	..	139 2 0

(d) *Recurring expenses of Tandem Roller*

Hire charges for 11 days @ Rs. 5/10/- per diem inclusive of pay of driver, chowkidar etc	..	61 14 0
Materials e g Petrol, Kerosine Oil etc	..	60 0 0
Total	..	121 14 0

(e) *Sundries e g mats etc for patch repairs.* .. 80 0 0

TOTAL OF (a), (b), (c), (d) AND (e) = Rs. 1071/2/- say 1071 0 0

Therefore, rate for 4 inches depth = Rs 8/11/- per hundred square feet.

(2) *Cost of Treatment to a depth of 6 inches*

Length = 3255 feet. Width = 6 feet

Area = 19,530 square feet.

(a) *Materials*

Cement 610 bags = 30 5 tons @ Rs. 38/- per ton ..1159 0 0

(b) *Departmental Labour*

Mates = 2 Nos × 16 days = 32 @ -/11/- per day	..	22 0 0
Beldars = 458 Nos @ -/7 6 each.	..	214 11 0
Mason for finishing 1 × 16 days = 16 @ 1/8/- per day	..	24 0 0
Mason's Beldar 1 × 16 = 16 @ - 7/6 per day	.	7 8 0
Bhisties for curing and applying water = 5 × 16 = 80 @ -/7 6 per day.	..	37 8 0
Total		305 11 0

(c) *Recurring expenses of Caterpillar*

Hire charges = 16 days @ Rs 2 8 - per day.	..	40 0 0
Driver's wages = 16 days @ Rs. 3 - - per day.	..	48 0 0
Assistant's wages = 16 days @ - 10 - per day	..	10 0 0
Chowkidar's wages for 16 days @ -/7/6 per day.	..	7 8 0
Materials, Diesel Oil etc	..	80 0 0
Total	..	185 8 0

(*d*) *Recurring Expenses of Tandem Roller*

Hire charges including wages of driver and chowkidar = 16 days @ Rs 5/10/-	..	90	0	0
Materials e g Kerosine oil, Petrol etc.	..	80	0	0
Total	..	170	0	0

(*e*) *Sundries*

Materials for curing, patch repairs etc	.	100	0	0

TOTAL OF (*a*), (*b*), (*c*), (*d*) AND (*e*)	..	1920	3	0

Therefore, rate for 6 inches depth = 9/14/- per hundred square feet

The delegates then proceeded to Najafgarh to see the new rural road from Najafgarh to Delhi Gurgaon Road *via* Basant This work was included in the Delhi Province Rural Road Programme

General The construction of new rural roads in Delhi Province is designed to open up the rural areas to an extent which has, perhaps, not been attempted in other parts of India It is definitely believed that the correct treatment of a suburban rural area is to provide a really good system of communications which coupled with widespread consolidation of holdings, should enable the people to take the fullest advantage of the urban markets lying within a few miles of their villages There is no doubt that the work so far done is greatly appreciated and that the further extensions to the rural road programme will be valuable not only from the economic but also from the administrative point of view

For the construction of the new rural roads, the labour has been drawn largely from the surrounding villages The fact that the work being done was entirely for their benefit was quickly appreciated by the men employed and after a few weeks training they adapted themselves to the task, and offered the most willing co operation With the exception of the construction of masonry and concrete works, the entire scheme was carried out by local labour and thus their interest has been maintained throughout

The entire rural road programme vide Annex I opposite, has been financed from the Road Development Fund. Owing to the depression since 1932 ordinary revenues have suffered and large grants to local bodies, a feature of the previous decade, could not be made The Road Fund came therefore, as a timely measure and the development of communications in Delhi Province is being financed from this fund

Land Acquisition The new Roads have followed largely the alignment of the old District Board Roads (as noted below), the nomenclature of the estimates being ' Raising and Metalling" of old District Board Roads

1. Najafgarh-Bahadurgarh Road
2. Nangloi Dhandasa Road *via* Najafgarh
3. Chiragh Delhi Road



Figure 4 Shaping to correct cross section and rolling

DELHI DISTRICT MAP.

Scale

BAKHTAWARPUR

GRAND TRUNK ROAD

CHEORA

Rohtak road

Pembari bridge

NAJAFGARH

Najafgarh road

PALAM

DELHI

4 Maqbara Park Auchandi Road
5 Najafgarh Mehrauli Road *via* Kapa Sera and Mehpalpur
6 Narela Bawana Gheora Road

The total width of land acquired was 80 feet throughout except where the road passed through villages or where religious buildings came within the road width The cost of acquisition varied with the nature of the land and this valuation was undertaken by the Land Acquisition Collector The earth for the embankment was dug from land temporarily acquired outside the permanent land width of the road In co operation with the Anti Malaria and Health authorities, the maximum depth of these borrow pits was restricted to one foot. As soon as the bank was completed to the full height and section the land temporarily acquired was handed over to the cultivators for ploughing This resulted in its being levelled and obliterated the depressions or borrow pits so that no source of mosquito breeding remained With few exceptions, the rural roads constructed or under construction pass through cultivated areas The land on which crops stood was not touched until they had been harvested and the bank in these reaches was built later

Mode of Construction The actual mode of construction of these rural roads is dealt with in detail later Like most of India s roads they have been built of stone and ballast consolidated whilst wet, (water bound macadam as it is technically termed) The foundation soling for the rural roads was Delhi Quartzite hard stone procured from approved quarries The wearing coat consisted of 1½ inch gauge ballast and was laid in two layers of 4½ inches each the second coat being laid several months after the first

After the bank had been consolidated with a heavy roller (10 or 12 ton) and the surface graded longitudinally down the centre line with a level and all undulations removed the soling coat was spread It was carefully hand packed and the interstices filled in with smaller pieces of the same material The soling was then rolled On the completion of the consolidation of the soling bunds about 12 inches in width and 6 inches in height were first constructed along each edge of the width to be metalled to confine the edges of the metal and prevent its spreading out wards during consolidation These bunds were made of damp clay, carefully aligned and compressed with rammers to prevent any escape of the water used in consolidation

About 90 per cent of the metal was then spread between these clay fillets to the camber of the template—the metal before spreading being carefully freed from all extraneous matter The steam roller was then passed over the whole surface dry starting from the edges and gradually working in towards the centre The balance of the metal was later spread where necessary to correct the camber after which the whole surface was kept thoroughly watered and the rolling continued uniformly till the surface was hard and compact so that a light cart made no impression

After thorough consolidation the blinding materials were spread on the surface These were moorum and bajri which were evenly spread and watered and rolled The object of these blinding materials is to fill

the interstices between the metal and produce an even water-resisting surface When complete, the surface was watered daily for 14 days and traffic kept off the road

The earthen sides were then brought up to the required height, rammed and neatly finished off in straight lines at the junction with the metal and along the outer edge, with a slight outward slope The earth for these berms was burrowed from the continuous side drains of the boundary of the road width and not from pits

All these rural roads were being treated with surface dressing In Annexes II to V, brief descriptions of the materials used and their specifications are given The firms carrying out the surface treatment supply all the tools and plant themselves

The side slopes of the embankment have been kept at 1 in 5 throughout except where the bank was above five feet in height This slope was adopted as it has proved safe for cart traffic, and all fear of overturning of bullock carts has been entirely obviated The height of the embankment with few exceptions, has been kept at two feet above the adjoining field levels This was necessary to prevent the inundation of the roads during the monsoon The rain water now runs off the road into continuous storm water drain provided at the edge of the road boundaries and flows to the nearest drainage cut In the rare cuttings *pucca* brick pitched drains have been provided *Kutcha* earth drains have been found from experience to be useless in such cases as the earth from the sides of the cutting drops back and blocks the drain and necessitates constant clearing and maintenance at much expense Pitched drains have also been provided where the road passes through villages Culverts are built at suitable points and the drainage from the village passes under these to its previous outfall The beds of such culverts are pitched and provided with a small cement plastered cunnette for sullage water

It has been observed in the past that the heavily laden traffic coming on to the main roads from the villages tends to damage the edges of the *pucca* road To avoid this, in these rural roads the village road approaches were metalled within the road boundaries and a maximum gradient of one in 25 adopted These metalled portions are of great help to the draught animals in drawing their loads up, on to the pucca road In cases where the road crosses irrigation channels or divides the fields of the *Zemindars*, syphons have been provided under the roadway These are built of reinforced concrete "Hume" pipes with masonry chambers at each end, cement plastered inside The diameter of the syphon depends on the dischage it is required to carry The chambers are placed 40 feet apart where the embankment is not very high, and the syphons are laid at an easy gradient

Rural Roads constructed

The roads which have been built from the Road Fund are detailed in Annex I facing page 260 All the roads are open to traffic but work on the second coat of metalling on the Narela Gheora Road has just been completed and surface dressing will now be taken in hand From the statement, it will be seen that the average cost per mile varies due to the following causes —

(a) Variation in the tendered rates
(b) Value of the land acquired
(c) The number of bridges culverts, and syphons necessary

In surface dressing these macadam roads the first coat applied was a penetrative one Specifications of the meterials used for this work will be found in Annexes II to VI, pages 268 to 270

On the plan of Delhi Province facing page 261 the roads reviewed in this note have been shown The total milage of the roads completed and under construction is 67½ miles

The following figures may be of some interest —

India as a whole has one mile of metalled road for every twelve square miles or one mile for every 3200 acres under cultivation In both these calculations urban roads have been excluded

Delhi Province on the same basis had before this Rural Road Programme was started one mile for every 1920 acres and with the roads now ready has one mile for every 1215 acres and on the completion of the whole scheme in 1947 the figure will be one mile for every 960 acres

These statistics show a very encouraging improvement, but even so in the respect of her roads India has far to go before she reaches the standard of Great Britain, which has at present one mile for every 135 acres

Under the orders of the Chief Commissioner the District Board Works in the Delhi Province were transferred to the Public Works Department in about June 1938 Amongst these works were the upkeep and maintenance of village earth roads

The length of District Board earth roads is 47 miles 2 furlongs

Besides these there are many miles of village approach roads

Inspections of these roads revealed that at all seasons of the year they were difficult for traffic and during the monsoon this difficulty was aggravated The low level of the roads and the deep rutting caused by heavily laden carts made them streams during the rains and the traffic problem for the villagers was one not capable of easy solution

These difficulties have been lessened to a great extent by the use of a CATERPILLAR DIESEL NO 10 AUTO PATROL MACHINE This Machine was purchased at the beginning of the financial year 1939 at a cost of Rs 18 022 by the District Board The purchase was made through the Indian Stores Department It was transferred to the Public Works Department for the maintenance and upkeep of the District Board and village earth roads

The delegates saw the machine at work

Earth Roads —The tendency of earth roads to develop a wavy or corrugated surface furnishes one of the most difficult problems that the engineer has to face When this Department took over the roads it was found that the roadways had been allowed to become deeply rutted and very wavy under the action of traffic The surface had therefore, to be scarified and bladed into proper shape

Generally speaking the term Maintenance refers to the work required to preserve something in its original condition Satisfactory maintenance of road surfaces especially of the earth type calls for smoothening operations at frequent intervals This may be weekly or at more distant intervals depending upon the type of surface and the amount of traffic In this programme for the District Board roads the operator was assigned a definite length of roads which he patrolled at regular intervals

Caterpillar Auto Patrol—A brief description of the performance of this machine now follows The Auto Patrol is a combination of tractor and grader The advantage of the power controlled unit is that no great physical exertion is needed to operate the various controls of the cutting blade (turning lifting tilting) and the scarifier In all the operator has before him five controls for the operation of the blade besides the usual controls for the engine gears clutch brake etc It is a fast machine and travels quickly from job to job

Under the chassis of the machine a cutting blade is fixed This is controlled by the operator and can be lifted and tilted at will to any angle within the range of the machine With the engine located over the driving wheels the operator has a clear view of the blade and the work being done The mechanical controls are simple trouble free positive and accurate in action

If the road material is packed too hard for the blade to handle or the soil is excessively hard it can be loosened with the scarifier and then regraded and reshaped with the blade Briefly the scarifier consists of a number of teeth fitted into a holder fixed at an angle so that the points strike the surface obliquely Its function is to tear up the hard surface prior to blading This scarifier is fitted to the chassis of the machine and the teeth are very important If they are to retain their cutting point for a reasonable length of time they must be made not only very hard but also very tough They must neither bend nor break and to fulfil these requirements are made of special steel

Establishment—The establishment with the machine is one mechanic operator and a capable fitter cleaner The latter helps to clean and oil the machine daily for the operator who cannot be expected to do this in addition to his ordinary work Some extra *beldars* had to be engaged where very deep ruts were encountered as these had to be filled with earth prior to the passage of the Auto Patrol

Cost of working—The machine commenced work on the 24th April 1939 The detailed expenditure from that date to the 31st March 1940 has been noted in Annex VII page 271 The machine was idle for 100 days in all for overhauling operator s absence on leave and on sundays The machine worked for 241 days The total milage of roads maintained was 374 miles *vide* Annex VIII page 272 Dividing the total expenditure for this period by the number of miles of roads maintained we get Rs 10 5 as the cost per mile—a surprisingly low figure It may be noted that this should not be taken as the best performance of the machine The comparatively slow progress made in the first year was due to the very bad condition of the roads It is hoped that better progress will be made during the current year

Fuels and Lubricants—The following is a list of fuels and lubricants which used on the Auto Patrol have given satisfaction —

Fuel	High Speed Diesel Oil
Lubricating Oil	Shell Ardol

For the engine the firm recommends any good quality oil with a viscosity of S A E 20 Castrol Oil was used For the gears Burmah Shell Oil was used

The two serious disadvantages which have been observed in the working of this machine are the absence in the equipment as purchased of means of

(a) Consolidating the road

(b) Watering of the prepared surface

It is intended when funds permit to purchase the additional equipment

It has been found that unless there is a certain amount of moisture in the soil the working of the machine produces a somewhat dusty surface There is a roller attachment which is a standard part and can be fitted to the Auto Patrol itself in place of the blade Such a roller filled with water weighs about 3340 pounds but the ground pressure obtained when using it is equivalent to about 10 000 pounds on account of the downward pressure from the machine itself This would make for extremely good rolling

No standard watering attachment is manufactured but one can be built locally An ordinary watering cart device can be attached to and towed behind the Auto Patrol and water sprayed while the rolling is being done With this the dust nuisance would be over come and better consolidation obtained in the earth roads thereby considerably improving them There is already an attachment at the back of the machine for the towing of a water tank device

The delegates next inspected some experiments with Digboi bitumen to the following specifications The material is straight bitumen supplied by Messrs Burmah Shell Company and is an Indian product obtained in Assam

(i) *Specification for single coat Local Digboi Bitumen 60/70*

The work was started on 19 6 40 and completed on 20-6 40 The road surface was cleaned with soft brushes to remove the surface dust It was then cleaned with wire brushes to loosen the mud and moorum from the interstices upto a depth of ¼ inch The surface was then cleaned with soft brushes to remove the dust produced by the above operations This was afterwards dusted by gunny bags and the edges of the road defined by means of 1 inch thick rope 100 feet long Depressions on the road were made good by patching before the

commencement of work On this cleaned surface Digboi Bitumen 60/70 heated to 350 degrees Fahrenheit was applied by means of a spraying machine at the rate of 45 pounds per hundred square feet and blinded over with 5½ cubic feet of ⅜ inch stone chips and rolled with a 10 ton steam road roller After this operation the road was opened to traffic

(ii) *Specification for double coat Local Digboi Bitumen 60/70*

The work was started on 20 6 40 and completed on 21 6 41 The road surface was cleaned with soft brushes to remove the surface dust It was then cleaned with wire brushes so as to loosen the mud and moorum from the interstices to a depth of at least ¼ inch Then the road surface was cleaned with soft brushes so as to remove the dust produced by the above operations This was afterwards dusted by gunny bags and the edges of the road defined by means of ½ inch thick rope 100 feet long Depressions on the road were made good by patching before commencement of the work On this clean surface Digboi Bitumen 60/70 heated to 350 degrees Fahrenheit at 35 pounds per hundred square feet was applied with a spraying machine and blinded with 3½ cubic feet per hundred square feet of fine ⅜ inch hard blue stone ballast in the first coat and rolled with a 10 ton steam road roller After this the entire painted surface was again thoroughly cleaned and all sur plus loose material and dust etc removed

The painted surface was again treated with hot Digboi Bitumen heated to 350 degrees Fahrenheit at 20 pounds per hundred square feet This was applied with a spraying machine and blinded with ⅜ inch Delhi quartzite chips at the rate of 3 cubic feet per hundred square feet for the second coat and rolled with a 10 ton steam road roller The road was then opened finally to traffic

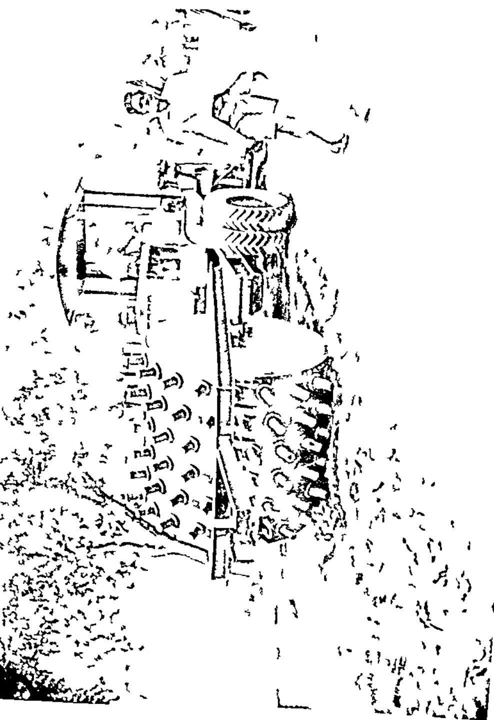
(iii) *Specification for single coat Local Digboi Bitumen 80/100*

The work was started on 22-6 40 and completed on 23 6-40 Specification and the procedure are the same as for (i) above except that Local Digboi Bitumen 80 100 was used instead of Local Digboi Bitumen 60/70

(iv) *Specification for double coat Local Digboi Bitumen 80/100*

The work was started on 23 6 40 and completed on 24 6 40 The specifications and procedure are the same as for (ii) above except that Local Digboi Bitumen 80/100 was used instead of Local Digboi Bitumen 60/70

A census of traffic to which these treatments have been subjected was taken for a period of about one month The results are attached



TRAFFIC COUNT

Milage.—Mile 24 3 near Level Crossing on Mehrauli Najafgarh road.

Nature of Road Surface.—Painted with Digboi Bitumen

Width of Road Surface.—10 feet

Width of Formation.—30 feet

During 24 hours ending	Total weight in tons			Weight in tons per yard width of hard surface		Total
	Motor	Others	Total	Motor	Others	
25 11-40	15 90	27 20	43 10	4 77	8 16	12 93
26 11-40	49 20	15 55	64 75	14 76	4 66	19 42
27-11 40	22 45	10 50	32 95	6 73	3 15	9 88
28-11 40	68 45	18 70	87 15	20 53	5 61	26 14
29 11 40	104 90	15 60	120 50	31 47	4 68	36 15
30-11 40	50 20	44 00	94 20	15 06	13 20	28 26
1-12 40	28 05	10 70	38 75	8 41	3 21	11 62
2 12 40	65 80	14 70	80 50	19 74	4 41	24 15
3-12 40	34 80	16 85	51 65	10 44	5 05	15 49
4 12 40	28 00	16 35	44 35	8 40	4 90	13 30
5-12 40	13 90	35 65	49 55	4 17	10 69	14 86
6 12 40	27 55	15 00	42 55	8 26	4 50	12 76
7 12 42	21 55	13 95	35 50	6 47	4 18	10 65
8-12 40	31 60	36 55	68 15	9 48	10 97	20 45
9-12 40	22 45	6 30	28 75	6 73	1 89	8 62
10 12 40	28 80	32 90	61 70	8 64	9 87	18 51
11 12 40	28 60	26 05	54 65	8 58	7 81	16 39
12 12 40	33 25	48 70	81 95	9 97	14 61	24 58
13 12 40	23 30	18 30	41 60	6 99	5 49	12 48
14-12 40	24 85	19 60	44 45	7 45	5 58	13 03
15-12-40	21 70	23 70	45 40	6 51	7 11	13 62
16 12 40	12 25	25 00	37 25	3 67	7 50	11 17
17 12 40	27 00	40 45	67 45	8 10	2 13	20 13
18-12 40	16 50	20 55	37 05	4 95	6 16	11 21
19-12-40	39 30	19 45	58 75	11 79	5 83	17 12
20 12-40	18 35	28 30	46 65	5 50	8 49	13·69
Total for 26 days	858 70	600 60	1459 30	257 57	179 84	437 41
Average per day	33 03	23 10	56 13	9 91	6 93	16 84

ANNEX II

SPECIFICATION FOR TWO COAT PAINTING WITH BURMAH SHELL MATERIAL

1 The road surface will be thoroughly cleaned of all dung dust, etc by swing wire brushes and country whips

Material to be used per hundred square feet —

2 First coat F 70 or Shelspra @ 20 pounds
grit @ 2 cubic feet
Second coat Spramex @ 30 pounds
grit @ 4 cubic feet

3 The work to be rolled carefully with a power roller

ANNEX III

DOUBLE COAT SURFACE PAINTING PRIMING COAT WITH SOCONY LIQUID ASPHALT NO 2, AND SUBSEQUENT COAT WITH SOCONY HOT ASPHALTUM

General —This specification covers the treatment of water bound surfaces with a priming coat of Socony Liquid Asphalt No 2, and retreatment with a subsequent coat of Socony Asphalt

Materials —The primer used shall be Socony Liquid Asphalt No 2 which is a cutback Asphalt containing 70 per cent bitumen by weight and is applied without heating The subsequent paint coat shall be Socony Asphalt, Grade 104 or 105

The cover coat for the primer shall be Badarpur sand, stone chips passing ½" sieve blinding the hot asphalt coat

Procedure —The surface to be treated must be in good condition true to grade and camber Any depressions shall be made good by patching before the commencement of work

The surface shall be thoroughly cleaned with wire brushes bass brooms etc and the interstices opened up to a depth of at least ¼ inch

First Coat —On the cleaned surface, Socony Liquid Asphalt No 2, shall be applied at from 20 to 25 pounds per 100 square feet This *priming application shall preferably be allowed 24 hours to penetrate* and shall afterwards be covered with Badarpur sand at 2 to 3 cubic feet per hundred square feet No rolling is necessary and the road can then be opened to traffic

Second Coat —After the priming coat has been under traffic for a period of at least seven days and not exceeding two months the surface shall be cleaned of all surplus sand loose materials etc, and given an application of Socony Asphalt, Grade 104 and 105 heated to 375 degrees Fahrenheit at 25 pounds per hundred square feet This shall be blinded with stone chips (¾" to ½") at from 3 to 3½ cubic feet per hundred square feet, and after rolling shall be considered as complete and opened to traffic

ANNEX IV.

SPECIFICATIONS FOR TWO COAT PAINTING ON WATER-BOUND MACADAM (1ST PENETRATIVE COAT AND SECOND ORDINARY HOT PROCESS COAT) WITH SHALIMAR TAR NO 2

First Coat —The road surface shall be cleaned with ordinary brooms or soft brushes with long handles to remove the surface dust It shall then be cleaned with wire brushes so as to loosen the mud and moorum from the interstices of the road Then the surface shall be cleaned with soft brushes so as to remove the dust produced in the above operation Finally the fine dust shall be removed with gunny bags When the surface has been thoroughly cleaned the edges of the road shall be defined by means of ½ inch thick ropes each 50 to 100 feet long Shalimar Tar No 2 (heated to 200 to 220 degrees Fahrenheit) shall be applied at the rate of 36 pounds per hundred square feet and blinded with stone chips at the rate of 3½ cubic feet per hundred square feet (in two operations) Immediately after the chippings have been spread the surface shall be rolled to set

The traffic shall be opened 24 hours after the work has been completed

Second Coat —Second coat shall be applied within 3 to 6 months after completion of the first coat (it depends on the census of the traffic) After cleaning the road surface thoroughly Shalimar Tar No 2 (heated to 200 to 220 degrees Fahrenheit) shall be applied at the rate of 24 pounds per hundred square feet and blinded with stone chips at the rate 2½ cubic feet per hundred square feet Immediately after the chippings have been spread the surface shall be rolled to set

The traffic shall be opened 24 hours after the work has been completed

Total material to be used per hundred square feet

Shalimar Tar No 2	60 pounds
Stone chips	6 cubic feet

ANNEX V

SPECIFICATIONS FOR PAINTING ROAD SURFACE COMPLETE WITH TWO COATS ON WATER BOUND MACADAM (BOTH WITH HOT PROCESS)

1 The road surface would be cleaned of all moorum and mud with wire and broom brushes in order to expose the stone metal

2 When the surface is thoroughly dry and clean Hotfix heated to 360—400 degrees Fahrenheit should be applied at the rate of 30 pounds per hundred square feet and covered with 3½ cubic feet of ½ inch stone chips and thoroughly rolled

3 When sufficient length of road has thus been treated, a second coat of Hotfix should be sprayed over at 20 pounds per hundred square feet and topped with 2½ cubic feet per hundred square feet of stone chips ⅜ inch and downwards

The surface should then be lightly rolled and the road opened to traffic

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ANNEX VI.

TWO COAT PAINTING ON WATER-BOUND MACADAM SURFACE (FIRST PENETRATIVE COAT AND THE OTHER *ORDINARY SURFACING COAT*)

Bitumuls Wearing Surface ½-inch depth

Clean the surface of the roadway thoroughly Fine material should be removed from the interstices of the base metal to a depth of at least ¼ inch for a water-bound macadam road Patch any holes or depressions with crushed *metal and Bitumuls H*

Sprinkle Road Surface with water.

	Per 100 square feet
On the dampened surface, Spray Bitumuls H	@ *23 pounds*
Immediately after spraying, spread ¾ — ⅜-inch chips	@ 3 5 cubic feet.
Wait 1 hour or longer, Dragbroom and roll lightly, Spray Bitumuls H	@ 27 pounds.
Immediately after spraying, spread ⅜ — ⅛-inch chips	@ 2 0 cubic feet.
Wait 1 hour or longer, Dragbroom and roll to finish	

Total materials per hundred square feet .—

Blue Delhi Stone grit	5 5 cubic feet.
Bitumuls H.	50 pounds.

The above specification was followed in a portion of Mile 12 Najafgarh Road as an experimental measure in 1934 in the Provincial Division and has since been adopted on several roads in the Central Public Works *Department. This is an ideal specification for water-bound roads* on which there is heavy traffic.

ANNEX VII.

STATE OF EXPENDITURE INCURRED ON RUNNING EXPENSES OF AUTO PATROL MACHINE DURING THE PERIOD FROM 24 4 39 TO 31-3 40.

(A) MATERIAL

Serial No	Description of material used	Quantity	Cost	Remarks
			Rs	
1	Diesel Oil for high speed engines	798 gallons	702	
2	Mobil Oil Castrol C	20 gallons	73	
3	Shell Ardol	90 gallons	196	
4	Kerosine Oil	24 gallons	30	
5	Petrol	3 gallons	5	
6	Grease	64 pounds	32	
7	Cotton Waste	47 pounds	9	
8	Country soap	39 bars	31	
9	Petty purchases	L S	50	
10	Sparking plugs	4 Nos	9	
11	Hand pump	1 No.	5	
12	Gear Oil B O C Burmah Shell	90 gallons	175	
	Total		1317	

(B) ESTABLISHMENT.

1 Pay of Auto Patrol Driver, from 24 4 39 to 31-3 40 — 11 months & 7 days @ Rs. 90/- P M = Rs 1011/-

2 Pay of Asstt Operator, from 24-4 39 to 31 3 40 — 11 months & 7 days @ Rs 20/ P M - 225/-

3 Pay of five beldars to work with the machine

$5 \times 14 \times \left(11 + \frac{7}{30} \right)$ 11 months & 7 days @ Rs 14 - P M = 786 -

Total expenditure for establishment = Rs 2022/-

TOTAL EXPENDITURE (A)+(B) = 1317 + 2022 = Rs. 3339 -

Say Rs 3340 -

Expenditure incurred on running and maintenance of Auto Patrol Machine during 1939 40 .. Rs 3340 -

Number of miles dressed by the Auto Patrol Machine = 324 miles.

EXPENDITURE INCURRED PER MILE = $\frac{3340}{324}$ or Rs 10 5/ per mile

ANNEX VIII.

LIST OF ROADS MAINTAINED BY THE AUTO PATROL MACHINE DURING THE PERIOD FROM 24-4-39 TO 31-3-40.

Serial No	Name of Roads dressed	Thana	Approximate length of road in miles	Number of trips done on each road	Total miles dressed	Remarks
1	Mehrauli to Mehrauli Bund ..	Mehrauli	1	1	1	
2	Mehrauli Gurgaon Road to Gadipura ..	Mehrauli	3	2	6	
3	Mehrauli Gurgaon Road to Ghatorni ..	Mehrauli	1	1	1	
4	Mehrauli Gurgaon Road to Yahyanagar ..	Mehrauli	1½	1	1½	
5	Tughlakabad Encamping ground to Khirkee .	Mehrauli	2	1	2	
6	Hauz Rani to Qutab Road via Begampur ..	Mehrauli	2	1	2	
7	Hauz Khas to Munirka village	Mehrauli	3	1	3	
8	Tughlakabad Kalka Road ..	Mehrauli	5	5	25	
9	Badarpur Jaitpura Road .	Mehrauli	3½	1	3½	
10	Rangpuri village Road .	Mehrauli	1½	1	1½	
11	Shamalka Rajokri Road .	Mehrauli	2½	1	2½	
12	Delhi Gurgaon Road via Basant to Naugal Dewat ..	Mehrauli	1	1	1	
13	Palam Railway Station to Kakraula bridge ..	Mehrauli	5	3	15	
14	Najafgarh to Kichaun Kalan village ..	Najafgarh	1½	1	1½	
15	Najafgarh to Pindwala Kalan via Paprawat ..	Najafgarh	5	2	10	
16	Najafgarh to Dhasa Road to Mundhels and Kair ..	Najafgarh	4	1	4	
17	Najafgarh to Ujwa village Kilkapur Roata and Jhantikra ..	Najafgarh	9	3	27	
18	Naugal Raya Palam Road ..	Najafgarh	2	1	2	
19	Shahdra Loni Road ..	Shahdra	4	1	4	
20	Shahdra Ghonda via Batarpur ..	Shahdra	4	1	4	
21	Ghonda to Jumna Bridge ..	Shahdra	2	1	2	
22	Jhil Kulanja Khureji Patpargunj	Shahdra	5	2	10	
23	Patpargunj to Shahdra ..	Shahdra	4	1	4	
24	Narela Bawana Road ..	Narela	5	1	5	
25	Narela Khankhoda Road ..	Narela	4	1	4	
26	Nangli Poona Khera Kalan & Khurd ..	Narela	4	1	4	
27	Khera Khurd to Hulimbi Khurd	Narela	2	1	2	
28	Barwala village to Khera Khurd	Narela	3	1	3	
29	Auchandi Road tail to Mangashpur ..	Narela	2	1	2	

Serial No	Name of Roads dressed	Thana	Approximate length of road in miles	Number of trips done on each road	Total miles dressed	Remarks.
30	Daryapur Kalan to Nangal Thakran ..	Narela	1	1	1	
31	Mangeshpur to Jaunti village	Narela	9	1	9	
32	Nangloi Pembari Bridge Road..	Nangloi	5	1	5	
33	Mundka Rani, Khera and Karela	Nangloi	4	1	4	
34	Pembari bridge to Punjab Khera	Nangloi	14	1	14	
35	Gheora Bawana Road ..	Nangloi	8	1	8	
36	Tikri Kalan, Jharauda Kalan Khair ..	Nangloi	7	1	7	
37	Approach road to Tekhand village ..		1	1	1	
38	Approach road to village Ali ..		1	1	1	
39	" " " Deoli ..		2	3	6	
40	Mehrauli Dera Mandi Road upto Punjab Boundry ..		8	3	24	
41	Approach road to Patwarkhana Mehpalpur .		1	1	1	
42	Approach road to Patwarkhana Kotla Mubarikpur .		2	1	2	
43	Approach road to Cemetery at Alipur ..		1	1	1	
44	Approach road to Dispensary at Ojwa from Qazipur ..		2	1	2	
45	Approach road from Dhasa road		3	1	3	
46	Approach road from Mittroan mile 20/2 ..		3	1	3	
47	Approach road to Cemetery at Patparganj ..		4	2	8	
48	Approach road to Deoli Bund to Tughlakabad ..		5	2	10	
49	Approach road to Khera Khurd		3	2	6	
50	Chawla to Qazipur, Isapur ..		1	1	1	
51	Pindwala Khurd to Pindwala Kalan ..		8	2	16	
52	*Narela Mandi* to *Hali-Rafiam* High School ..		1½	2	3	
53	Alipur to Narela Mandi ..		1	1	1	
54	Pindwala Kalan to Shahpur village ..		7	1	7	
55	Mehpalpur to Rangpuri ..		2	2	4	
56	Mehram Nagar to Mehpalpur Old pucca bund ..		2	1	2	
57	Doonda Heri to Rajkori ..		2	1	2	
58	Kapa Sera to Rajkori ..		2	1	2	
59	Palam road Tihar Bund ..		1	1	1	
60	Mehrauli Pali road upto Asula Bund ..		5	3	15	
			209		323½	

APPENDIX III.

A TALK ON SOIL STABILIZATION*

BY

S. R MEHRA, ASSOC M INST C E,

Executive Engineer, III Lahore Provincial Division, Lahore

I am very glad to have been asked today to address a representative gathering of Highway Engineers, on a subject which is not only going to occupy a very envious position in the science of Highway Engineering in the near future, but which has also given me personally, a great deal of anxious thought for over 3 years now

I have used the words "anxious thought' because *every time I have* tried to discuss the economic possibilities of soil stabilization with a Highway Engineer in this country, the engineer has given me the impression, that he is talking to me with his mind already made up that it is impossible to economically improve a soil for use on roads

There are many reasons of course, for the existence of a general "bias" against soil stabilization, if I might use the word

Firstly, the idea is not only new but is also revolutionary in character and is therefore subject to the general opposition that such ideas naturally get

The revolutionary nature of the idea lies in the fact that whereas heretofore *we have been considering the actual road crust as the essential* feature of the road design, and the sub grade or the natural soil has been considered in a very general and vague manner if at all in future, the *entire design of a road will have to be governed principally by the nature* of the sub grade

Many failures of roads have *in the past been attributed to poor* workmanship and bad design of the pavement, although they were directly due to unsuitable sub grades It is the sub grade, which is to ultimately carry the traffic loads *If the sub-grade is firm and capable of uniformly* good behaviour in changing moisture conditions a thin flexible pavement is all that is required over it If, on the other hand, the sub grade has a weak *supporting power* and is also *subject to* large volumetric changes with changing moisture conditions, it will probably be necessary to have a fairly strong, rigid pavement over it, something like a thick reinforced concrete slab with a definite "beam strength" So that, before the nature or the thickness of the road crust can be determined, it is absolutely necessary to know what the sub grade is going to be

*This talk was given by Mr Mehra at the New Delhi Town Hall at 10 00 on Monday 27th January 1941, and is referred to on page 204 Appendix II of this book

The second reason for this bias is the complete failure of past experiments on soil stabilization. Experiments have in the past been carried out by individual engineers who owing to insufficient knowledge of the subject of soil science have had to depend entirely on the specifications given by the various firms manufacturing stabilizing materials. In their efforts to boost their own materials the firms seem to have unwisely advocated the use of one kind of stabilizer indiscriminately for all kinds of soils and their main concern seems to have been not the improvement of the soil but the use of their products. This short sighted policy naturally resulted in the treatments being unnecessarily expensive and also in very discouraging failures.

Thirdly there is a general scare of the bullock cart in this country and the impression seems to be that so long as all bullock carts do not use pneumatic tyres (which is an impossibility) it is no use trying to improve the unmetalled road because no unmetalled road will stand bullock cart traffic. Whereas the bullock cart is certainly a menace to any kind of light pavement the problem is not so hopeless as it is generally considered to be.

To begin with the intensity of the bullock cart traffic on the road has to be considered. On the one hand there may be only 5 to 10 bullock carts a day running on a road on the other hand there may be as many as 500 or more on another road. Whereas it may not be possible to improve the soil sufficiently to take up the heavier traffic it may be worth while trying to do so for the lighter one. Again the bullock carts in all areas are not iron tyred. About 90 per cent of the bullock carts in most Punjab districts have wide wooden tyres and there seems to be an increasing tendency to give up the iron tyre.

Taking the above two points into consideration it can be safely assumed I think that there is a large milage of roads immediately *available which if provided with cheap stabilized soil pavements* can withstand prevailing traffic this milage will of course go on increasing as the agriculturist and the engineer get a better comprehension of their respective responsibilities in the solution of the problem in course of time.

Yet another reason for the bias is the lack of a common code of practice for soil stabilization in this country and the general confusion which has been created in the minds of the road engineers by the various schools of thought.

The only system of soil research which is both consistent and practicable is the one called The American System. This system is used with modifications of course to suit local requirements in all Western countries where soil science is the craze of the day. I have been working on this system myself for about five years now and it is my pleasant duty today to try and convince you of what I have just said about this system.

America was the first country many years ago to start a systematic study of soil and in 1924 on the creation of the Central Road Research Bureau soil science was kept as one of its branches. The American

research was originally based mainly on laboratory tests of the physical properties of the top soil

The Russian attempts to establish *scientific principles for sub grade* investigations originated at a very much later date than the American ones The Russians made use of American experiences and improved on their methods It was in Russia where for the first time a systematic study was made of the intimate relations which exist between the soil the physiographic character of the landscape and the climatic conditions Present American research on soils recognizes this relationship

Independent soil research is now being vigorously carried out, besides America and Russia in England, Germany, Switzerland Sweden, Norway Holland and Belgium, etc , where I was able to discuss soil stabilization problems at length, with soil physicists and soil engineers, both in the laboratories and out in the field during my 18 months' tour in 1936 and *1937, and it is universally* accepted that a *soil* must be *studied* both *in* the laboratory and in the field, before its behaviour under traffic can be anticipated to any degree of accuracy

The time at my disposal being short, I shall today confine myself only to the technique of stabilized soil roads

According to the American system a soil is a conglomerate of sand silt and clay in much the same way as cement concrete is a conglomerate *of shingle, sand and cement A soil has its coarse material its filler* and its binder in much the same way as concrete, and the grading of the mix has an important effect on the behaviour of the soil in the same way as the grading of materials affects the strength of concrete

The sand provides internal friction to the soil in the presence of moisture, the silt provides embedment of the sand grains and the clay provides cohesion in the dry weather

The very first thing to do when a soil road is to be improved, is to go out at site and to travel along the road, making field investigations The local people or preferably the old road coolies and mates, etc , should be closely questioned about the behaviour under traffic in varying weather conditions in each "reach" where visual inspection shows a change of soil texture If a "reach" is reported to behave badly in the dry weather but improves in the wet weather, the field conclusion is that it is rich in sand but deficient in binder clay If on the other hand a reach behaves well in the dry weather but breaks down in the wet, it is too rich in clay and deficient in sand *A road which behaves badly both in the dry and* the wet weather, consists of a soil which is predominant in cohesionless silt and is therefore deficient both in sand and binder clay

The next step would naturally be to look for the deficient ingredients in the close vicinity of the site Pit sand or sand from the beds of irrigation channels having a bed width of more than 10 feet is generally suitable for soil stabilization work As regards clay, you will find many a time that your men will tell you that there is no possibility of getting any clay near this vicinity or that, but take it as a tip from a man who can claim to have a fairly wide experience in this matter, that those people should

not be taken at their word and that you should personally try and look for clay deposits

I have carried out detailed soil survey of over 700 miles of road in the Punjab but I have not come across a single mile of road where a clay deposit does not exist within economic distance The largest distance I had to go for clay was 2 miles, which is not too much, considering that ordinarily only small quantities of clay are required to be added

Having collected samples in the field they are then brought down to the laboratory for analysis The sample having been air dried, is broken up into small fragments and a representative fraction taken out of it after mixing it up This fraction is then pounded with a pestle and a mortar taking care not to break any rock fragments The pounded soil is then passed through a nest of sieves, consisting of Nos 10 40 and 200 A S T M (American Society for Testing Materials) the shaking being done for about 10 minutes or so The material retained on the No 10 sieve is the coarse material, existing in the soil that retained on No 40 sieve is coarse sand that retained on No 200 sieve is fine sand, and the material passing through the No 200 sieve is a mixture of silt and clay

So that, the sieve analysis gives us the percentages of coarse material, coarse sand and fine sand in the sample and also the total percentage of silt and clay It is only fine sand which goes to make up the soil mortar This should be about 35 to 55 per cent of the total fraction passing through the No 40 sieve The coarse stuff goes to make up the grading of the granular material

Now for binder clay there are various ways of separating the clay fraction from the mixture of silt and clay passing through No 200 sieve These methods are all very laborious but ignoring that fact, even if the exact percentage of clay in the soil sample is determined it is incapable of giving by itself an indication of its effect on the behaviour of the soil. Clay may exist in a soil in a completely dispersed state or in varying degrees of flocculation and as such unless the degree of flocculation is also known in addition to the total percentage of clay its behaviour will be indeterminate Further the binding properties of clay are also governed by the quality of clay and its own grading Thus the effect of a certain quantity of clay in a soil is governed by so many unknown factors that it would serve no useful purpose to find out the percentage of clay as such

The cohesive property of a soil or, in other words the resultant effect of the quantity the quality the grading and the degree of flocculation of the clay present in it is therefore determined from its *plasticity index* which is the numerical difference between the *liquid limit* and *plastic limit* of a soil and represents the range of moisture contents within which a soil retains its cohesive properties

The *liquid limit* and *the plastic limit* of a soil are determined by means of simple laboratory experiments which are described on page 3 (5) of my paper entitled 'The use of Soil Stabilization in Metall Unmetalled Roads in India", read before the 5th Indian Roads Co

1939 at Calcutta, and printed in the Proceedings of the Indian Roads Congress, Volume V

For wearing courses which are not intended to be surface treated *plasticity indices* of about 8 to 14 are considered suitable, depending on the weather and traffic conditions of the locality, the lower number being used for wet places and the higher number for dry ones For foundation courses, a plasticity index of 4 to 7 is considered sufficient as it is *necessary to prevent softening from below by* capillary moisture

In practical designing the plasticity index required is therefore first to be fixed upon, in consideration of the traffic and weather conditions on the road *The proportions of admixtures to be added to the road soil* in the shape of sand silt or clay as the case may be, are then to be determined in the laboratory to give the required *plasticity index* Heretofore this has been done by the trial and error method But I have been trying to evolve a simple formula for correlating *plasticity index* with the percentages of ingredients of the soil mixture and this is calculated to make the designing of mixtures very straight forward I hope to publish in the near future a paper on the results of my investigations on these lines as soon as I have completed the work

So much for laboratory design As regards the purpose of soil stabilization, it is to provide unmetalled roads with sufficient abrasive resistance and shear strength to accommodate prevailing traffic under changing weather conditions without detrimental deformation The shear strength is provided by the soil mortar *viz*, the fraction passing through the No 40 sieve *No stable soil however, is capable of withstanding the* abrasive action of traffic to any appreciable extent It is therefore necessary to add a small quantity of hard granular material in order to provide abrasive resistance to the soil About 30 to 40 per cent of such material will generally be found sufficient and will also give additional shear strength to the road crust

The materials suitable for use as granular material, are stone chips gravel or kankar, if available at site, or fine brick ballast

The granular material should be well graded and the following grading is recommended as a general guide —

	Percentage *by weight*
Retained on 1" screen .	0 per cent
Passing 1" screen but retained on ¾" screen	10 per cent
Passing ¾" screen but retained on ¼" screen	50 per cent
Passing ¼" screen but retained on No 10 sieve	30 per cent
Passing No 10 sieve	10 per cent

It will not always be possible to get this grading economically in actual practice and therefore this is to be used only as a general rough guide

In most places, due to non availability of natural granular material at site, fine brick ballast is to be used The snag in the use of fine brick metal, however, is that the hand breaking of it to the required size and grading is an expensive affair and further research in this direction in burning soil in the form of thin sticks which are easily breakable or in crushing brick bats with special mechanical crushers, is necessary If means can be found of obtaining fine brick metal cheaply on the road side it will help the soil stabilization problem greatly The present average cost of such material is in the neighbourhood of Rs 14 per hundred cubic feet on the road side, but there is no reason why it should not be possible to produce it for Rs 7 - or Rs 8/- per hundred cubic feet

In poorly graded soils such as silt, etc , in which it is not possible to provide the necessary grading due to inavailability of materials locally, the use of insoluble binders like bitumens, tars bitumastic emulsions tar emulsions cement and the like is necessary for providing them with shear strength For surface abrasion however it would be necessary to give some kind of bituminous or tar surface treatment to a soil thus stabilized. The addition of granular material in this case will not solve the problem, because the soil mortar bound with an insoluble binder has no recuperative value

Coming down to actual construction the most important point is the moisture in the soil at the time of compaction For every soil mixture there is a definite moisture at which that particular mixture can receive the maximum possible compaction This moisture is called the Optimum Moisture for a soil mixture and should naturally be maintained as near as possible during compaction

As regards compaction itself by far the best way of doing it is by means of a *Sheeps Foot Roller* Whereas in the case of an ordinary flat roller the compaction is maximum at the top and falls rapidly with every inch of depth due to dispersion of load with a *Sheeps Foot Roller* the compaction starts from the bottom upwards and the whole thickness of the crust receives uniform compaction For a description of the theory and practice of *optimum moisture* its method of determination and the use and design of *Sheeps Foot Roller* you will please refer to pages 9f and 10f of my paper entitled Stabilization of the Unmetalled Berms of Metalled Roads read by me at the sixth Indian Roads Congress 1939 at Bombay printed in the Proceedings of the Indian Roads Congress Volume VI

The *Sheeps Foot Rollers* which are on the market are very expensive and have to be driven by a tractor and are, therefore, usable only on very big projects The design of a *Sheeps Foot Roller* given in the reference above is capable of local manufacture and will cost only about Rs 200/ This roller is very suitable for small scattered projects and can be easily pulled by a pair of bullocks

For the stabilization of narrow strips of Berms etc where a *Sheeps Foot Roller* cannot be used, a *Sheeps Foot Rammer* as shown at 16f of my paper referred to above (*vide* Proceedings, Volume VI useful

For compaction of mixtures containing a fair proportion of granular materials it is not necessary to use the *Sheeps Foot Roller* The various steps in the construction of a stabilized soil crust are fully described in my paper entitled The use of Soil Stabilization in the Metalled and Unmetalled Roads in India II * accepted for the present Indian Roads Congress It may be repeated however that the curing of the crust for a few days and its final compaction under traffic both to be under controlled moisture conditions are extremely important and should be carefully done

As regards the maintenance of stabilized soil roads a technique will have to be evolved from actual experience So far it seems that it is necessary to give the crust a heavy sprinkling of water once a month but unless several hundred miles of road have been maintained for several years it will not be possible to lay down any rules for maintenance of such roads

The use of hygroscopic chemicals for maintenance purposes is essentially a local problem The use of calcium chloride is prohibitive due to its high cost As regards common salt or sodium chloride which is not hygroscopic by itself but has certain hygroscopic impurities the chief one being magnesium chloride it could be suitably used in places which do not suffer from long spells of dry non humid weather The action of common salt is that it forms a hard thin layer of crystals on the road surface and as a result the rate of evaporation of moisture from the road crust is considerably retarded As it is now possible to obtain common salt free of duty it is for consideration whether in places which are not very dry and where water is not easily available on the road side common salt can be used economically for increasing the intervals between periodical waterings of the road

There is one aspect of unmetalled road construction that I must touch upon before I go on to the economical possibilities of soil stabilization namely the presence of detrimental salts in the soil By far the most important of these salts is sodium sulphate which is generally recognizable from the loose and fluffy condition of the soil in which it exists The theory of this detrimental action and the remedies proposed are dealt with fully in the reports of the Punjab Irrigation Research Institute published in the special Soil Roads Number of the Indian Roads† in its April 1939 issue

Before a soil is ever put on the road it is very necessary to be sure that it does not contain detrimental quantities of sodium sulphate For this it is necessary to have a simple method of finding the approximate percentage of sodium sulphate in a soil I do this in my laboratory by what I call the *Barium Chloride Method* and I find it very useful and simple *Barium chloride* reacts with sodium sulphate forming a white precipitate of barium sulphate the thickness of the precipitate depending on the quantity of *sodium sulphate* present The soil is shaken for a couple of hours with water 100 c c of water being added for every 10 grams of soil and filtered out Sufficient *barium chloride* is then added

* Printed in the Proceedings of the Indian Roads Congress Volume VII part I
† Indian Roads No XX pages 5 to 43

to the filtrate to precipitate out all the *sodium sulphate* The thickness of the precipitate is then compared with a series of precipitates produced with known quantities of *sodium sulphate* and kept in a series of test tubes the percentage varying by 5 per cent from 5 to 5 per cent By comparison of the precipitates it is thus always possible to find the percentage of *sodium sulphate* present in a soil correct within 0 25 per cent which is all that is required for practical purposes

As regards the economic possibilities of soil stabilization whereas heretofore there has been only either the fair weather unmetalled road or the expensive metalled road you could now have a series of roads of varying costs between the two extremes all these roads being fit for use in all weathers The usefulness of this to the various local bodies who cannot afford to construct metalled roads *in lengths which are not heavily* trafficked and yet which must be provided with all weather roads to *enable the agriculturist to get his* produce to the market as soon as possible can better be imagined than described

The diagram attached gives an idea of the various kinds of crusts that can be used for different traffic conditions along with their approximate costs

Another use of soil stabilization is on the unmetalled berms of metalled roads The bulk of our metalled milage has a metalled width of 9 to 12 feet the rest of the formation being *kachha* and with the increasing speeds of motor traffic the over taking or crossing of vehicles *is becoming increasingly dangerous both in the dry and the wet weather* At a cost of about Rs 90/ per foot mile it is possible to provide a stabilized soil crust about 5 feet on each side of the metalled width for a small total cost of Rs 900/ per mile as against Rs 12 000/ per mile for widening the metalling A detailed description of this kind of work is given on pages 149 to 151 of my paper* entitled Use of Soil Stabilization in the Metalled and Unmetalled Roads in India II accepted for the Seventh Indian Roads Congress 1940 held at Delhi

Stabilized soil could also very economically be used as a foundation for metalled roads in place of ordinary brick soling at about 25 per cent of its cost and could give much better distribution of load

Before I close I am going to make what will appear at first to be a staggering statement My feeling is that a stabilized soil road is not only many times cheaper than the water bound macadam road but also provides a better crust for surface treatment than does the water bound macadam in as much as it is much less liable in course of time to the formation of local depressions and resulting unevenness of surface than is the water bound macadam

The reason for this is obvious In water bound macadam the crust depends for its strength on the interlocking *of the adjoining* pieces of broken stone In course of time under the vibration of traffic the sharp corners of adjoining stones by rubbing against each other gradually

* Proceedings of the Indian Roads Congress Volume VII Part 1 pages 149 [illegible]

get worn and the crust being cellular and full of voids, the pieces of metal with worn rounded corners, start settling down to new figurations, which cause slight depressions on the surface These depressions are in turn accentuated by virtue of the bumpiness they cause in the road In the case of stabilized soil, on the other hand, the soil having been compacted at optimum moisture to the maximum possible extent to start with and all pieces of granular material having a thin padding of soil round them, the phenomena of rubbing and consequent depression cannot possibly take place and the surface, therefore, stays comparatively much smoother The day is therefore not far, when we shall replace our water-bound macadam entirely by stabilized soil

The surface treatment of stabilized soil is a fairly straightforward process, the only essential being the use of a tack coat of cold penetration bitumen or tar, over which the surfacing can be done in the ordinary way.

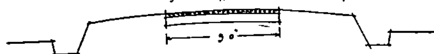
Having already obtained two extensions through the kindness of the president, I am afraid I cannot enlarge upon the various aspects of soil stabilization as much as I should like to, but if in this short talk I have convinced some of you, gentlemen, that the American System of soil research, as applied to roads, is not just an empirical method but is a practical consistent system with a scientific background and that it is worth giving a second thought, I shall feel that I have had a successful day

Before we go on to my demonstration road under construction, to see the various stages in detail under actual execution, I would like you, gentlemen, to have a look at the cuttings taken out of my various experimental lengths, after these lengths have been under traffic for about a year The traffic on one of the roads is as high as 1300 tons per 24 hours consisting mainly of bullock carts and heavy motor trucks

I thank you for a very patient hearing

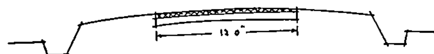
TYPE. I

5" LOOSE SOIL COMPACTED WITH SHEEPS FOOT ROLLER
WITH 40% GRANULER MATERIAL IMPREGNATED IN THE
TOP ½" ONLY COST Rs: 750/ PER MILE
9 WIDE TRAFFIC UP TO 100 TONS /24 HOURS



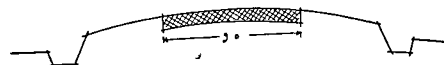
TYPE II

SAME AS TYPE I BUT 18 WIDE
TRAFFIC UP TO 200 TONS COST Rs 1000/ PER MILE



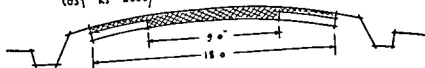
TYPE III

5 LOOSE SOIL MIXTURE 60% SOIL 40% GRANULER
MATERIAL 9 WIDE TRAFFIC UP TO 500 TONS
COST Rs 1250/ PER MILE



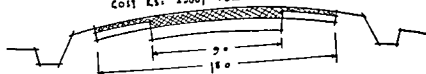
TYPE IV

CENTRE 9 SAME AS TYPE III
4½ WIDE BERMS SAME AS TYPE I
TRAFFIC UP TO 750 TONS
COST Rs 2000/ PER MILE.



TYPE V

CENTRE 9 FOUNDATION COURSE 5 LOOSE SOIL MIXTURE
COMPACTED WITH SHEEPS FOOT ROLLER
WEARING COURSESAME AS TYPE III
4½ WIDE BERMS SAME AS TYPE I
TRAFFIC UP TO 1000 TONS
COST Rs. 2500/ PER MILE



TYPE VI

SAME AS TYPE V BUT SURFACE TREATED
WITH TAR OR BITUMINOUS BINDER
TRAFFIC UP TO 2000 TONS